Commonwealth of Massachusetts

Central Artery (I-93)/ Tunnel (I-90) Project

Operating Certification of the Project Ventilation System

Technical Support Document

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Prepared For
Massachusetts Turnpike Authority

by
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ACO	Administrative Consent Order
AIS	Air Intake Structure
CA/T	Central Artery/Tunnel
CEM	Continuous Emissions Monitoring
cfm	Cubic Feet Per Minute
CMR	Code of Massachusetts Regulations
CO	Carbon Monoxide
CTPS	Central Transportation Planning Staff
DAHS	Data Acquisition Handling System
DST	Dewey Square Tunnel
EMRPA	Eastern Massachusetts Regional Planning Area
EOT	Executive Office of Transportation
EOTC	Executive Office of Transportation and Construction
EPA	US Environmental Protection Agency
ER	Environmental Re-evaluation
ESP	Electrostatic Precipitator Systems
FHWA	Federal Highway Administration
FSEIS/R	Final Supplemental Environmental Impact Statement/Report
hp	Horsepower
kcfm	Cubic Feet Per Minute (thousands)
Mass DEP	Massachusetts Department of Environmental Protection
MBTA	Massachusetts Bay Transportation Authority
MEPA	Massachusetts Environmental Policy Act
MHD	Massachusetts Highway Department
MMIS	Maintenance Management Information System
MPH	Miles Per Hour
MPO	Metropolitan Planning Organization
MTA	Massachusetts Turnpike Authority
NAAQS	National Ambient Air Quality Standard
NEMA	National Electric Manufacturers Association
NIST	National Institute of Standards and Technology
NMHC	Non-Methane Hydrocarbon
NMOG	Non-Methane Organic Gas
NO_2	Nitrogen Dioxide
NO_x	Nitrogen Oxide
NPC	Notice of Project Change
OCC	Operation Control Center
OLM	Ozone Limiting Method
PM	Particulate Matter
PM_{10}	Particulate Matter - 10 micron
ppm	Parts Per Million
QA/QC	Quality Assurance/Quality Control
slpm	Standard Liters Per Minute
SOPs	Standard Operating Procedures
TAZ	Traffic Analysis Zone
TEOM® monitor	Tapered-element oscillating microbalance sensing technology monitor
TSD	Technical Support Document
TWT	Ted Williams Tunnel
VB	Ventilation Building
VMT	Vehicle Miles Traveled
VOC	Volatile Organic Compound
vph	Vehicles Per Hour
$\mu g/m^3$	Micrograms Per Cubic Meter

Executive Summary

The Central Artery/Tunnel (CA/T) Project in Boston, Massachusetts includes approximately 160 lane-miles of new highway, of which approximately 3.6 miles (or 80 lane-miles) are underground tunnels. This includes the 7,900-foot-long, four-lane Ted Williams Tunnel (TWT) under Boston Harbor connecting South Boston and East Boston, the eight- to ten-lane underground Southeast Expressway (I-93), and the underground portions of the Massachusetts Turnpike (I-90). The entire CA/T Project was opened to general public use on March 5, 2005.

The CA/T's ventilation system utilizes a mixture of full-transverse ventilation and longitudinal ventilation. The vast majority of the tunnels operate as a full-transverse ventilation system. In the full transverse ventilation system, fresh air is introduced to the tunnels from under the roadway, and the exhaust air is extracted through openings in the tunnel ceilings to plenums located above the ceiling. The ventilation fans and auxiliary equipment that provide fresh air and exhaust air are housed in the six ventilation buildings (VBs 1, 3, 4, 5, 6, and 7).

The portion of I-93 called the Dewey Square Tunnel (DST) and eight exit ramps of the CA/T roadway are longitudinally ventilated. In the longitudinal ventilated tunnels, exhaust air moves in the direction of the traffic flow. In doing so, tunnel exhaust air is pushed through and out the exit portals of the tunnel by the piston action effect created by moving vehicles. In all, nine sections of CA/T roadway are ventilated to the outside air by longitudinal ventilation. Some longitudinally ventilated tunnels include supply air and jet fans mounted in the tunnel ceilings. Two VBs provide fresh air to two longitudinally ventilated tunnel sections (VB 8, and DST Air Intake Structure).

Massachusetts Department of Environmental Protection (Mass DEP) Regulation 310 CMR 7.38(2) states that no person shall construct a tunnel ventilation system and project roadway subject to 310 CMR 7.00 without first certifying to Mass DEP (and receiving Mass DEP written acceptance of that certification), that the operation of any tunnel ventilation system, project roadway and roadway networks will not cause a violation of certain specified standards, guidelines and criteria specified in CMR 7.38. On July 8, 1991, Mass DEP conditionally accepted the CA/T Project's Pre-Construction Certification. An Amended Pre-Construction Certification was conditionally accepted by Mass DEP on September 1, 2000. Under Mass DEP Regulation 310 CMR 7.38(4), the CA/T Project is required to file an Operating Certification for the Project's ventilation system ("Operating Certification"), which establishes emission limits for the exhaust from each VB and longitudinal ventilated exit ramp. The Operating Certification is required to be filed no earlier than 12 months and no later than 15 months after the entire CA/T Project was opened to public use. There are four parts to the Operating Certification:

- Part I – Ventilation System – Operation and Emission Limits
- Part II – Compliance Monitoring Program
- Part III – Record Keeping and Reporting
- Part IV – Corrective Actions

This Technical Support Document (TSD) provides specific information for the CA/T's Operating Certification. Mass DEP's Conditional Acceptance of the CA/T Project's Pre-Construction Certification required certain mitigation measures to mitigate potential air quality impacts from the CA/T Project and to meet the criteria set forth in the Ventilation Certification Regulation for proposed certification. As was demonstrated in the 1991 Pre-Construction Certification, and as is discussed in detail in the TSD, the CA/T Project, as currently constructed and operated, complies with all relevant air quality standards in the Project area. The data collected for the Operating Certification demonstrates that the CA/T Project has not had a negative effect on local air quality. Future CA/T data collected as part of this Operating Certification along with contingency measures outlined in this document, should demonstrate that the CA/T Project will continue to have a positive effect on local air quality. In addition, data collected for the Operating Certification also demonstrates that the CA/T Project, as currently constructed and operated, satisfies the criteria set forth in the Ventilation Certification Regulation for project certification, as demonstrated through actual measured emissions.

Part I describes in detail, the CA/T's ventilation system and pollutant emission limits that were established for the exhaust from the ventilation buildings and the longitudinally ventilated tunnel sections (DST and exit ramps). Since the Project tunnels are open for general public use under normal operation, the tunnel ventilation system has been designed with redundant ventilation capacity to adequately protect motorists traveling the tunnels. The established emission limits are being applied to day-to-day tunnel operation not including emergency situations during a tunnel fire.

Recently, exhaust plenum modifications have been made to the I-90 Connector after several exhaust plenum panels directly beneath the D-Street overpass of the eastbound Connector tunnel, near its exit portal, fell to the roadway below it. These modifications involved removal of exhaust panels within approximately 200 feet of the eastbound exit portal and within approximately 150 feet of the westbound I-90 Connector entrance portal. The small amount of emissions generated within the last 200 feet section, instead of being picked up by VB 5 as originally designed, will be carried forward directly into the open boat section between the I-90 Connector and Ted Williams Tunnel by the air flow created by vehicles exiting the tunnel (i.e., this short section will become naturally ventilated). Qualitative assessment of air quality conditions indicates that there will be no significant air quality consequences as a result of these modifications.

The emission limits for carbon monoxide (CO), nitrogen oxides (NO_x) and particulate matter smaller than 10 micron (PM_{10}) were determined as concentration-based emission limits (i.e., measured levels in parts per million [ppm] or micrograms per cubic meter [$\mu g/m^3$] inside the tunnels). Through dispersion modeling, using both the US Environmental Protection Agency (EPA) approved air models and wind tunnel test techniques, compliance demonstrations of the applicable ambient air quality standards and state guideline values (for CO, NO_2 and PM_{10}) have been made for all conditions when the tunnels are operated below these limits. Since there are no ambient air quality standards for volatile organic compounds (VOCs), 310 CMR 7.38 requires that the Project does not increase emissions over the No-Build scenario at a regional level. A regional emission inventory for the transportation sources included in the CA/T Project study area was performed for year 2005 including both the CA/T Build and No-Build scenarios. The results of this inventory indicate that the CA/T Project and transit projects completed by the Commonwealth to date, have resulted in the reduction of emissions versus the No-Build scenario.

The procedures used in these analyses, which have been approved by the Mass DEP (see Appendix F, "Mass DEP Correspondence"), are included in Appendix B, "Air Quality Analysis Protocol for Determination of Emission Limits as Part of the Operating Certification of the Project Ventilation Systems".

Part II of the TSD describes the CA/T's compliance monitoring program, including the Continuous Emissions Monitoring (CEM) system designed, constructed and installed to demonstrate compliance with established emission limits. The CEM system is operated independent of the CO monitors which were installed along the tunnel sections and are used to control the ventilation levels. These in-tunnel CO monitors are used to aid the operators to maintain safe air quality and visibility within the tunnels under normal operations and to control smoke and heat during emergency conditions.

Due to the low pollution levels inside the tunnels (i.e., higher than ambient but much lower than industrial stacks), the CEM system is considered a hybrid type of monitoring system, which incorporates appropriate elements of the federal regulations 40 CFR Part 58, 60, and 75 for both the ambient air quality monitoring systems and the continuous emission monitoring at power plants. Equipment certification and operations are specifically tailored for use in the Project's emission monitoring program, and its Initial Certification of the Project CEM Systems was performed in 2005. Attachment 1, "CEM Air Emissions Monitoring Protocol", provides specific information regarding CEM equipment that has been installed at each VB and longitudinal ventilated exit ramp as well as the operational protocol for the CEM equipment. The project-wide quality assurance and quality control (QA/QC) program has been developed through extensive technical consultation with the Mass DEP (see Appendix F, "Mass DEP Correspondence"). The procedures to be followed also take into account equipment manufacturer's recommendations as well as good engineering practice.

Vehicular emissions (i.e., CO) in the tunnel are monitored in the exhaust plenum of each ventilation zone prior to being discharged up and out of the building stacks and at the exit portal of each longitudinal ventilated exit ramps. In lieu of monitoring, the NO_x emission levels are estimated using the monitored CO emission levels measured at the plenum. CO–NO_x correlation models were developed based on the statistical analysis of several thousand hours of monitored data for both pollutants at the TWT. The PM_{10} emissions are monitored at four representative locations where the highest PM_{10} levels have been identified.

Part III describes the record keeping and reporting aspects of the CA/T's Operating Certification. All CO and PM_{10} CEM data are recorded continuously at each CEM location and the data is downloaded via a modem to a central PC. These data are reviewed and daily data summaries for each month are generated. Using the daily summaries, NO_x emission concentrations are developed using the Project-specific CO to NO_x conversion ratio.

In support of the Operating Certification, seven months of these CEM data (i.e., October through April 2006) are included in this document. Starting in May 2006, these data will be compiled and submitted to the Mass DEP on a monthly basis for the period from May 2006 through October 2007, and on a quarterly basis thereafter.

As part of the Operating Certification requirements, the CA/T Project is also collecting and recording traffic data in the mainline tunnels. Hourly and daily traffic volumes for both directions in I-93 and I-90 are being recorded and will be submitted monthly to Mass DEP from October 2006 to October 2007, and on a quarterly basis thereafter.

Part IV of the TSD describes corrective actions that will be taken by the Massachusetts Turnpike Authority (MTA) in the unlikely event that any of the established emissions limits are exceeded due to non-emergency traffic conditions. Written notification of an exceedance, along with the actions that have been taken to eliminate it, will then be submitted to the Mass DEP.

Current peak-hour traffic volumes using the mainline tunnels (i.e., I-93 & I-90) are between 60 to 80% of the projected year 2010 peak-hour levels. The Project tunnel ventilation system currently is operating at 13% of its exhaust capacity during off-peak and night hours and at 23 to 32% capacity during peak hours. There is thus more than sufficient capacity in the Project's ventilation system to address future increase in emissions.

Hourly CEM data have been collected since October 2005 and the results indicate that the measured CO concentrations range from 1 to 6 ppm during off-peak and as high as 26 ppm during peak periods. The NO_x levels range from 0.3 to 0.8 ppm in the off-peak hours and from 1.3 to 3.2 in the peak hours. The measured average daily PM_{10} concentrations are in between 29 and 153 $\mu g/m^3$ and the measured maximum daily concentrations range from 49 to 365 $\mu g/m^3$. Some of the measured peak PM_{10} levels have been associated with the nighttime construction activities related to the tunnel leaks. The levels are expected to get lower once the repair and construction process is finished.

To ensure compliance with the emission limits from any location, CEM emission action levels (i.e., 75 to 80% of the emission limit) have been established for each of these locations. Project operating experience indicates that acceptable tunnel CO concentrations can be effectively maintained by step-wise small increases in the ventilation rate.

Based on the Project's already efficient ventilation design, in particular, the abundant available capacity in the Project's ventilation system, as concluded from recent operating experience and implementation of the emission action levels, emission excursions are considered to be an unlikely event. Therefore, specific information regarding the mitigation plan are not included as part of this Operating Certification. However, should an excursion(s) in an emission limit(s) routinely occur because of normal traffic conditions, and the steps outlined in the contingency plan become ineffective in eliminating the excursion(s), and pursuant to 310 CMR 7.38(6) Mass DEP finds that one or more criteria set forth in 310 CMR 7.38 are being violated or likely to be violated, then MTA will develop and submit to the Mass DEP, a mitigation plan as required under 310 CMR 7.38(6).

Part I – Ventilation System – Operation and Emission Limits

1 DESCRIPTION OF CENTRAL ARTERY/TUNNEL PROJECT VENTILATION SYSTEMS

The Central Artery/Tunnel (CA/T) Project has been designed to alleviate existing problems regarding traffic congestion, accidents, and related air pollution in the Boston area by replacing the elevated portions of the Central Artery with new aboveground and underground roadways. Figure 1-1 provides the physical limits indicating the above and underground portions of the Project

Approximately 3.6 miles (or 80 lane miles) of these new roadways are underground tunnels, including the 7,900-foot-long, four-lane Ted Williams Tunnel (TWT) under the Boston Harbor that connects East Boston to South Boston, the eight to ten lane underground Southeast Expressway (I-93), and the underground portions of the Massachusetts Turnpike (I-90). The TWT was opened to commercial and other authorized vehicles on December 15, 1995, and the entire Project was fully opened to general traffic in March 2005.

As described in the 1991 Project-wide Final Supplemental Environmental Impact Statement/Report (FSEIS/R) and the Preferred Alternative in the 1994 FSEIS/R for the Charles River Crossing, the CA/T Project utilizes a full-transverse ventilation system to maintain acceptable in-tunnel air quality set forth by the Federal Highway Administration (FHWA) for motorists traveling in the tunnels.

In response to authorization from the FHWA in November 1995 regarding the use of the longitudinal ventilation system, the Massachusetts Highway Department (MHD) implemented design refinements to the Project's tunnel ventilation system by using jet fans as a potentially viable alternative for maintaining adequate ventilation. Specifically, the refinements included the replacement of the full-transverse ventilation systems with longitudinal ventilation at Dewey Square Tunnel (DST) section of I-93 Southbound, and at eight tunnel exit ramps.

1.1 VENTILATION SYSTEM DESIGN CRITERIA

Tunnel ventilation systems servicing the CA/T Project have been designed to provide adequate ventilation capacity during both normal traffic operation and emergency/fire conditions. The urban setting of the Project also imposed significant demands on the tunnel ventilation system design and its allowable impact to the surrounding community. Sensitivity to land use and ambient environmental issues such as noise and air quality weighed heavily in determining the allowable size and locations of the necessary ventilation facilities. Full transverse and longitudinal type ventilation systems were therefore utilized to meet both the functional demand of the various road tunnel configurations and the local environmental challenges in the most cost effective and efficient manner.

The design followed the FHWA-Environmental Protection Agency (EPA) in-tunnel air quality criteria, which were established based on time exposure of the motorists traveling inside the tunnel. Based on these criteria; the tunnel operator is required to maintain CO levels below 120 part per million, when the time exposure does not exceed 15 minutes during peak rush hour traffic, 65 ppm for exposure between 15 and 30 minutes, 45 ppm for 30 to 45 minutes, and 35 ppm when the motorists could remain 60 minutes inside the tunnels. The estimated average time for a vehicle traveling inside the tunnel is less than 9 minutes during PM peak hour conditions and is shorter for AM peak hour conditions.

FIGURE 1-1: PHYSICAL LIMITS OF CA/T PROJECT

From a tunnel ventilation perspective, the Project is best defined as three distinct and separate road tunnel "systems": the Ted Williams Tunnel, the I-90 Tunnel Extension and the I-93 Central Artery Tunnel. Each of these tunnel systems has been divided into multiple "ventilation zones". Each ventilation zone is served by a dedicated and independently controlled set of fans. This concept allows for significant operational flexibility throughout the Project and provides the means for establishing the most efficient system operation under normal conditions and the most effective system operation in the case of a traffic incident or fire emergency.

The tunnel ventilation system was designed with a supply air capacity of 65 cubic feet per minute (cfm) per lane-foot of tunnel, and an exhaust capacity of 100 cfm per lane-foot of tunnel. The total supply capacity for the full transverse ventilation system (including all six ventilation buildings [VBs]) is approximately 11.4 million cfm serving the 22 ventilation zones. This ventilation system was designed (15 years ago) to maintain in-tunnel CO levels between 20 and 60 ppm, and NO_x levels between 1 and 5 ppm, during normal peak hour traffic conditions. Due to the advances in emission control technology and the public's demand for cleaner air, new car emissions are progressively decreasing. Therefore, the CA/T Project ventilation system is expected to provide ample ventilation to accommodate the anticipated traffic growth.

1.1.1 Full-Transverse Ventilation

In the full-transverse ventilation system, fresh air supply is introduced to the tunnels from under the roadway, and the mixture of vehicle exhaust is extracted through openings in the tunnel ceilings to plenums located above the ceiling before being diverted up through the VB's exhaust stacks. Figure 1-2 provides a schematic of the full transverse ventilation system.

1.1.1.1 System Description

The full transverse ventilation system includes six VBs (1, 3, 4, 5, 6, and 7) serving 22 ventilation zones with their supply and exhaust fans. The system includes a total of 73 exhaust stacks each one connected to an exhaust fan. The system also includes VB 8 which provides only supply air to Ramp CN-S. Figure 1-3 provides a typical cross section for VB 4. Figure 1-4 provide the locations of the VBs.

The sections of the Project served by each VB are as follows:

- VB 1 serves a section of I-90 Westbound / Eastbound, and Ramps D & L. It has four ventilation zones, 11 exhaust stacks, and a supply capacity of 1.66 million cfm.
- VB 3 serves a section of I-93 Northbound / Southbound. It has three ventilation zones, 14 exhaust stacks, and a supply capacity of 2.44 million cfm.
- VB 4 serves a section of I-93 Northbound / Southbound. It has four ventilation zones, 16 exhaust stacks, and a supply capacity of 2.48 million cfm.
- VB 5 serves a section of I-90 Westbound / Eastbound. It has four ventilation zones, 12 exhaust stacks, and a supply capacity of 1.98 million cfm.
- VB 6 serves a section of the TWT Westbound / Eastbound. It has two ventilation zones, 6 exhaust stacks, and a supply capacity of 1.16 million cfm.
- VB 7 serves a section of the TWT Westbound / Eastbound, and Ramp T-AD. It has five ventilation zones, 14 exhaust stacks, and a supply capacity of 1.68 million cfm.

Figures 1-5 to 1-10 provide the location of each VB.

FIGURE 1-2: SCHEMATIC OF FULL-TRANSVERSE VENTILATION SYSTEM

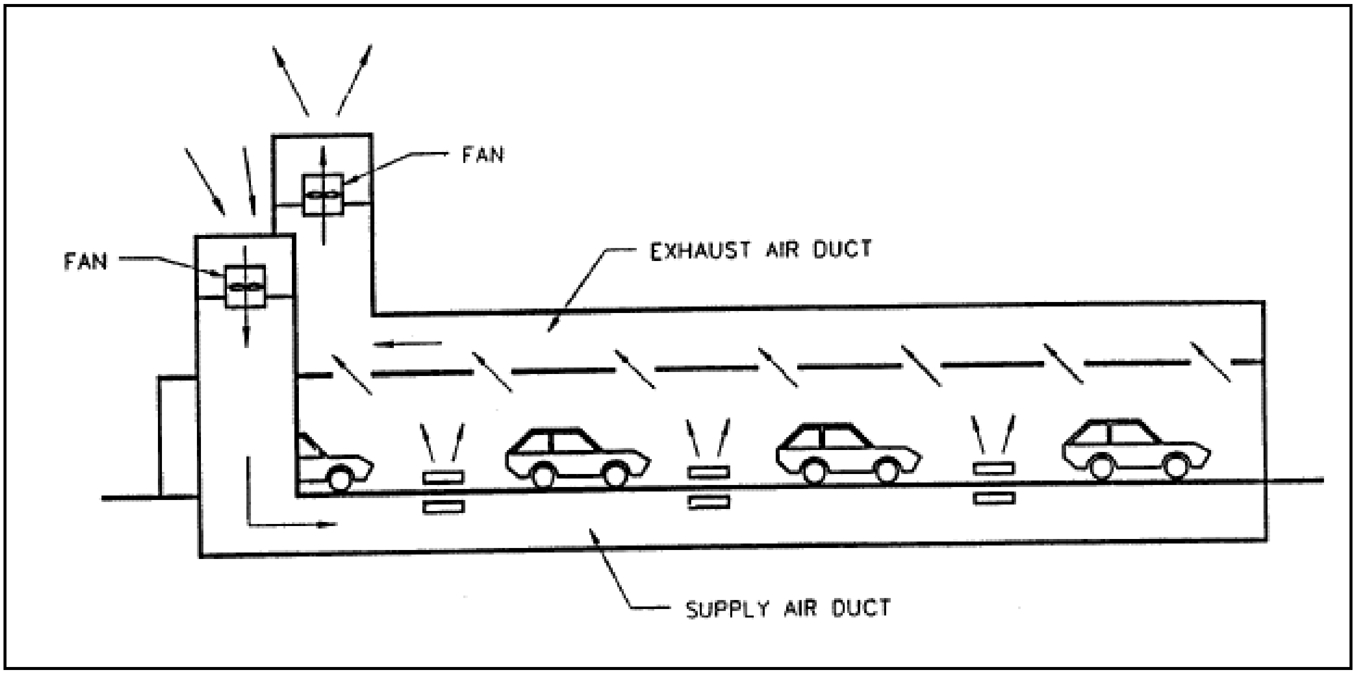


FIGURE 1-3: VENTILATION BUILDING 4 VENTILATION SCHEMATIC DIAGRAM

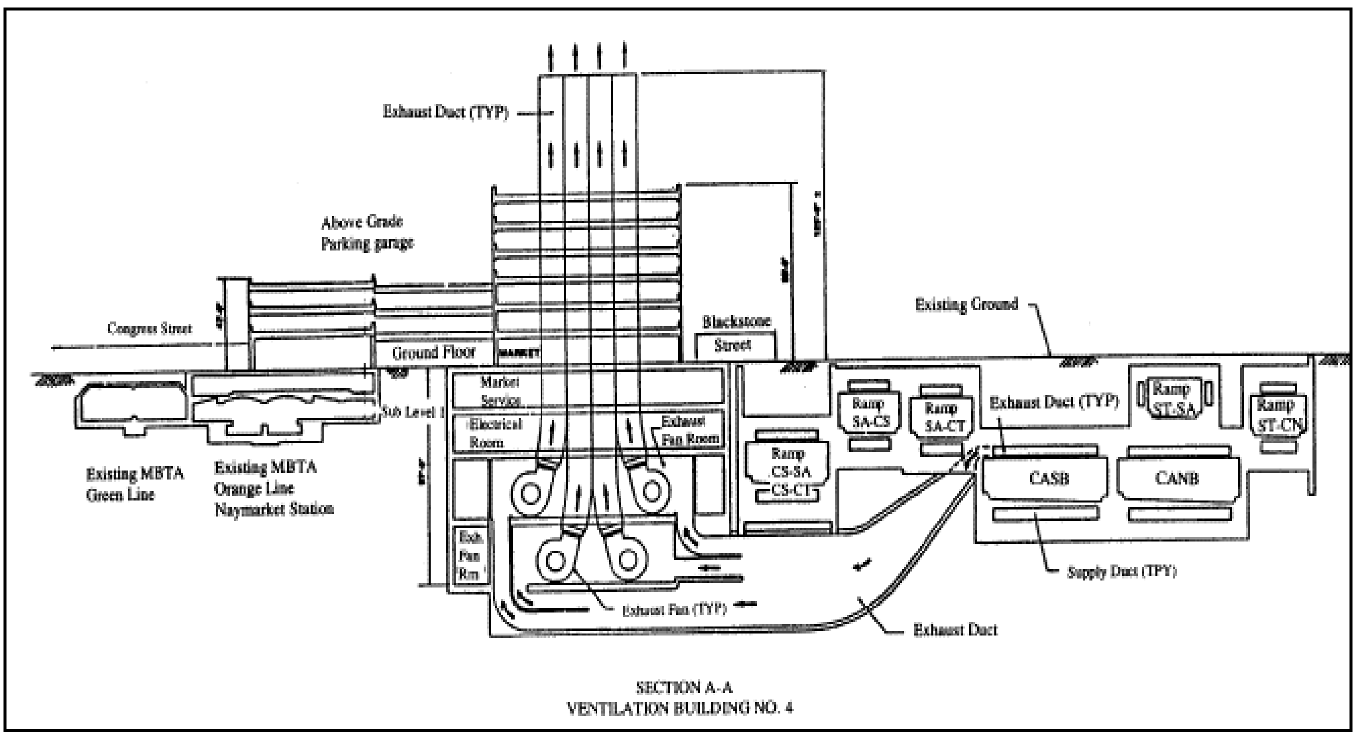


FIGURE 1-4: LOCATION OF VENTILATION BUILDINGS

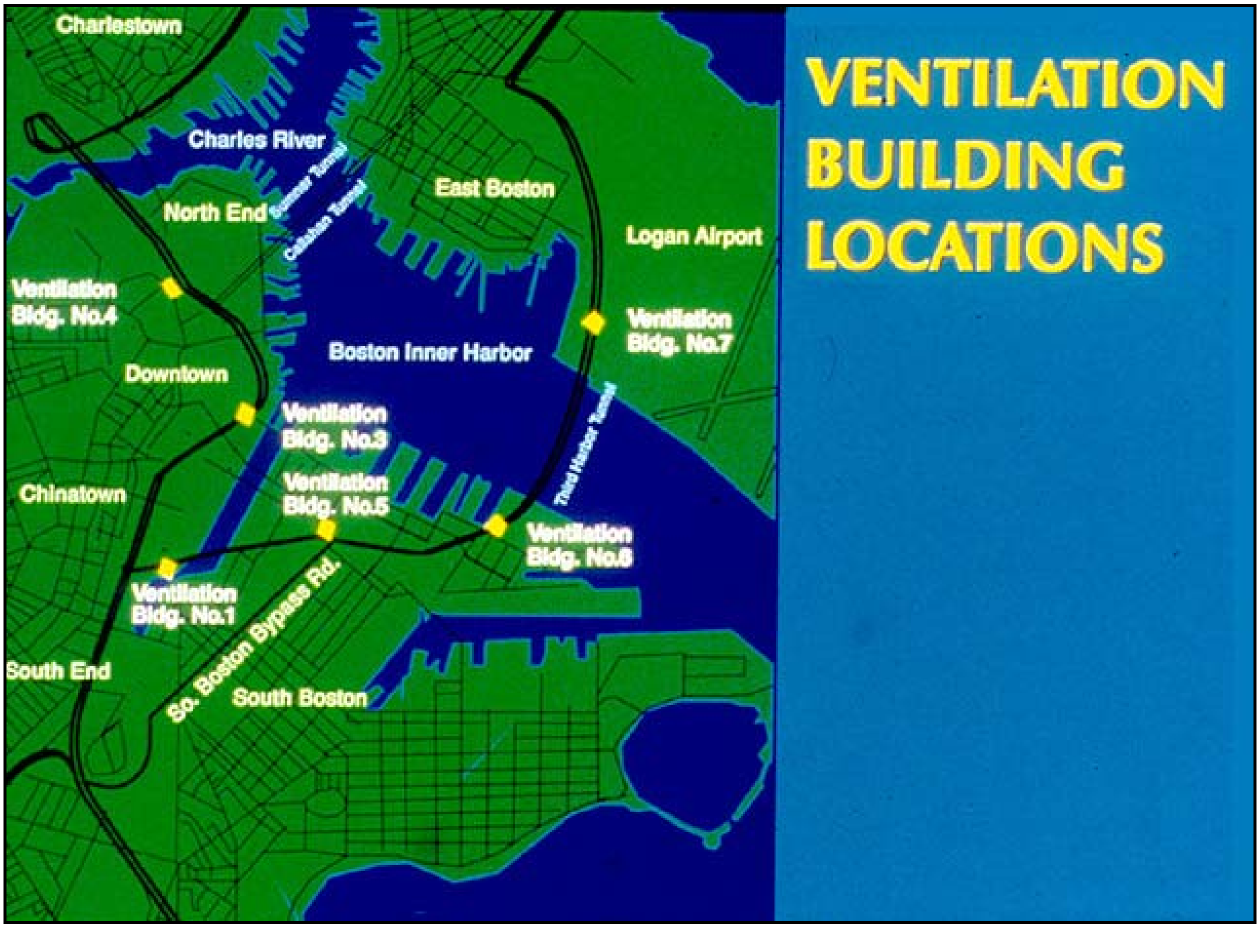


FIGURE 1-5: LOCATION OF VENTILATION BUILDING 1

FIGURE 1-6: LOCATION OF VENTILATION BUILDING 3

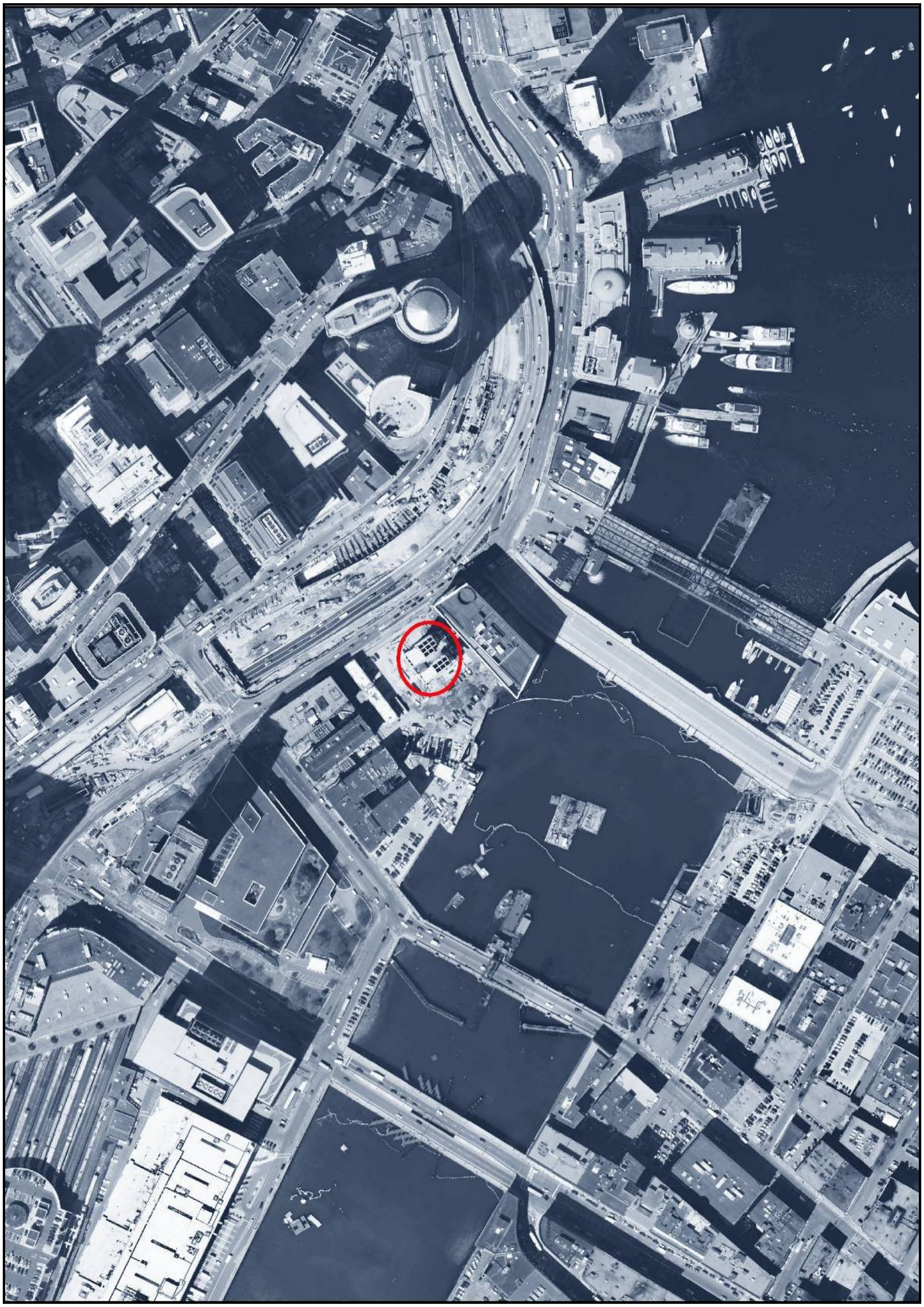


FIGURE 1-7: LOCATION OF VENTILATION BUILDING 4

FIGURE 1-8: LOCATION OF VENTILATION BUILDING 5

FIGURE 1-9: LOCATION OF VENTILATION BUILDING 6

FIGURE 1-10: LOCATION OF VENTILATION BUILDING 7

The airflows for the full-transverse system are controlled by the many supply and exhaust fans. Airflows are set from the ventilation control system located in the CA/T Project's Operation Control Center (OCC) in South Boston, and is determined by the CO levels monitored inside each ventilation zone.

1.1.1.2 The I-90 Connector Exhaust Plenum Modifications

On July 10, 2006, several exhaust plenum panels directly beneath the D-Street overpass of the eastbound I-90 Connector tunnel, near its exit portal, fell to the roadway below it. As a result of the accident, the remaining exhaust panels within approximately 200 feet of the eastbound exit portal and approximately 150 feet of the westbound I-90 connector entrance portal have been removed.

This section provides a qualitative assessment of air quality conditions associated with the removal of the aforementioned exhaust panels.

As designed, vehicular emissions inside the CA/T project tunnels are collected by the tunnel ventilation system and exhausted into the plenum and then into atmosphere via exhaust stacks. There is no change in emissions from vehicles traveling inside the affected portions of the tunnel sections and these emissions are very small when compared to the total VB 5 emissions.

Because of eliminating 200 feet of the eastbound exhaust plenum, vehicle emissions generated inside this tunnel portion will be carried forward directly into the open boat section between the I-90 Connector and Ted Williams Tunnel by the air flow created by vehicles exiting the tunnel. The boat section is approximately 35 feet below street level and most of these emissions will remain inside the boat section. These emissions will either continue traveling farther into the eastbound entrance portal of the Ted Williams Tunnel or will get re-circulated by westbound traffic back into the I-90 Connector. A small portion of these emissions will also migrate up and out of the boat section. Emissions that are carried forward into the eastbound Ted Williams Tunnel will be picked up by VB 6 and exhausted to the atmosphere through its exhaust stacks. Those emissions that are drawn back into the I-90 Westbound Connector will be exhausted through VB 5.

As discussed in Section 1.1, the project's tunnel ventilation system has been adequately designed to maintain safe in-tunnel air quality for motorists traveling through these tunnels. Subsequent Continuous Emissions Monitoring (CEM) of carbon monoxide (CO) inside the project ventilation buildings and the exit ramps, as reported in Section 5.5, validates the project ventilation system design. Based on nine months of CEM data collected at VB-5 and VB-6 between October 2005 and June 2006, the maximum observed hourly CO levels are well below 15% level of their respective allowable emission limits presented in Section 2.6. During this period ventilation system needed to operate only at 25% of its fresh air supply capacity level.

Because of the adequate fresh air supply and exhaust capacity of the project ventilation system, minimal emissions shifting between VB 5 and 6 due to the I-90 Connector exhaust plenum modifications will result in negligible changes to the CO levels at these ventilation buildings. Consequently, no significant change to ambient air quality in the surrounding areas can be expected.

1.1.2 Longitudinal Ventilation

In the longitudinal ventilated tunnels the exhaust air moves in the direction of the traffic flow, and it is pushed through the exit portals by the piston action effect created by the moving vehicles. Longitudinal ventilation applies to the DST section of I-93 Southbound, and at eight tunnel exit ramps.

Some of these tunnel exit ramps are connected to the supply air from the VBs, and others have supply air in the form of jet fans mounted inside the tunnel ceilings and walls. In all cases, these tunnels are self-ventilated when the traffic flow moves at a speed that ranges from 20 to 45 miles per hour (MPH) (i.e., the traffic movement provides the majority or totality of the ventilation air). In the cases of traffic congestion, stalled conditions or incidents, the mechanical ventilation (supply air and/or jet fans) supplements and/or replaces the natural self-ventilation system.

The fans that assist the longitudinal ventilation airflows are also controlled from the CA/T Project's OCC in South Boston, and they are manually operated according to the CO levels monitored inside each section of these tunnels.

1.1.2.1 Dewey Square Tunnel

The original DST was designed and operated for approximately 49 years as a longitudinally ventilated tunnel. Under normal traffic conditions, the tunnel is ventilated by the piston effect of the vehicles traveling through the tunnel.

The newly reconstructed tunnel (which is connected at its northern end to the new CA/T I-93 southbound tunnel) includes an Air Intake Structure (AIS) housing two centrifugal fans (300 horsepower (hp) and 300,000 cfm each). The AIS located above the DST alignment slightly south of Congress Street to provide supply air in cases of roadway accidents or stalled traffic conditions.

In addition, in order to provide operator flexibility with respect to air flow management for normal and emergency operations, three of the four existing DST fan chambers and shafts were retained and rehabilitated with reversible axial fans which typically operate in the supply mode. In the instance of a fire condition, these eight reversible fans (100 hp and 100,000 cfm each) will be operated in exhaust mode to prevent "back layering" (movement of the hot air and combustion gases counter to the desired direction of flow) of the smoke, protecting vehicles and passengers stopped behind the incident location.

The current DST exit portal is located 100 feet south of Kneeland Street (Figure 1-11). The future location of the portal under the full commercial development scenario will be an additional 300 feet further south, on the South side of the South Station Connector (also identified in Figure 1-11).

1.1.2.2 Exit Ramps with Fresh-Air Supply and/or Jet Fan Ventilation

There are eight longitudinally ventilated ramps, of which three include supply air and jet fan ventilation, and the other five (which are not connected to the mainline tunnels) only include jet fans.

The longitudinally ventilated ramps are as follows:
- Ramp LC-S (Leverett Circle to Central Artery SB)
- Ramp SA-CN (Surface Artery to Central Artery NB)
- Ramp CN-S (Central Artery NB to Storrow Drive)
- Ramp ST-CN (Sumner Tunnel to Central Artery NB)
- Ramp ST-SA (Sumner Tunnel to Surface Artery)
- Ramp CS-SA (Central Artery SB to Surface Artery)
- Ramp CS-P (Central Artery to Purchase Street)
- Ramp F (I-90 WB to Congress Street)

The three ramps connected to supply air include:
- Ramp CN-S which has supply air provided by two fans (280,000 cfm) located inside VB 8.
- Ramp CS-SA which is connected to the I-93 southbound and has supply air from VB 4.
- Ramp CS-P which is also connected to the I-93 southbound, and has supply air from VB 3.

Figures 1-12 to 1-17 identify the location of each ramp.

FIGURE 1-11: LOCATION OF EXISTING AND FUTURE DST EXIT PORTAL

FIGURE 1-12: LOCATION OF RAMP PORTALS 1(L-CS) AND 3 (SA-CN)

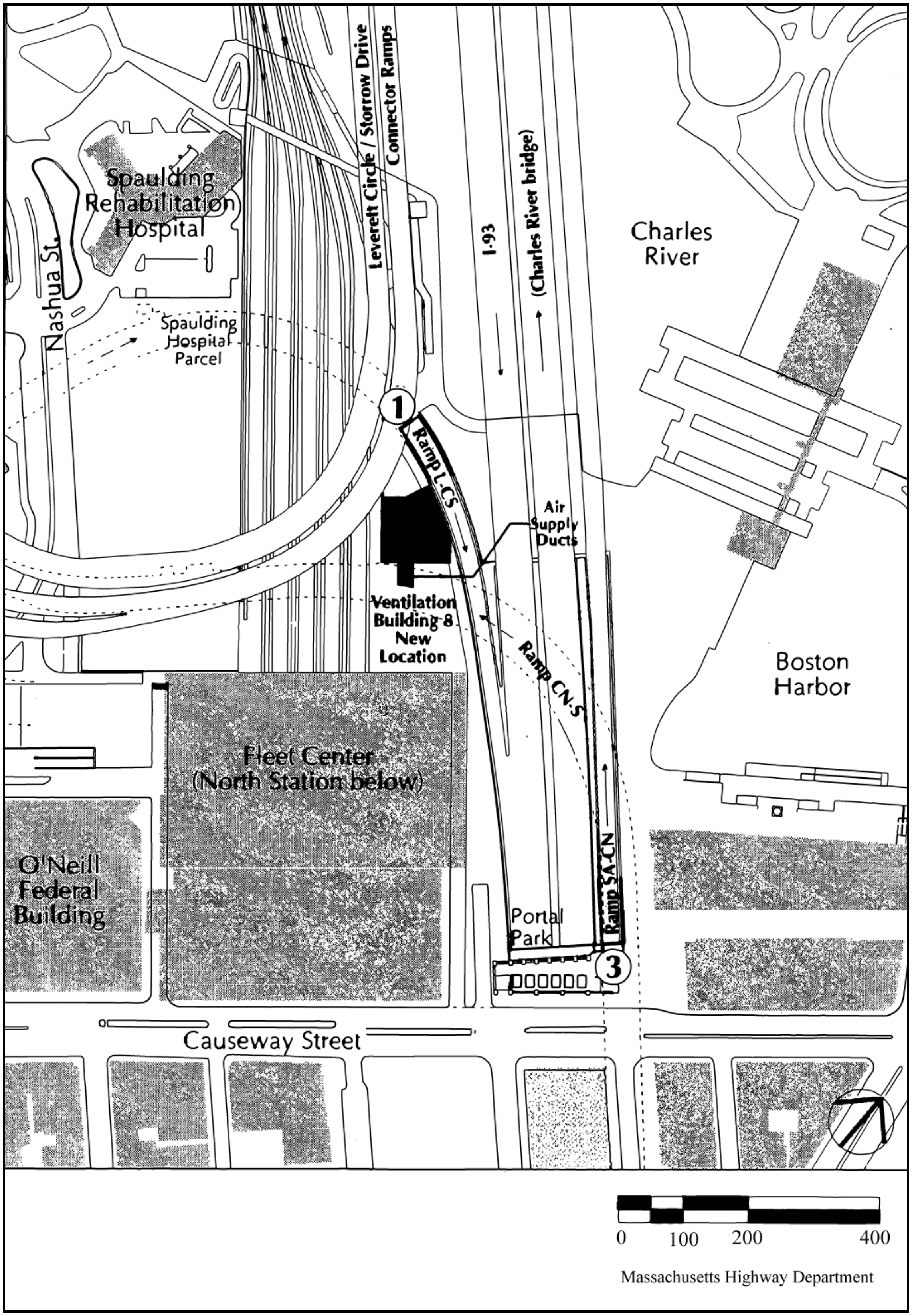


FIGURE 1-13: LOCATIONS OF RAMP PORTAL 2 (CN-S)

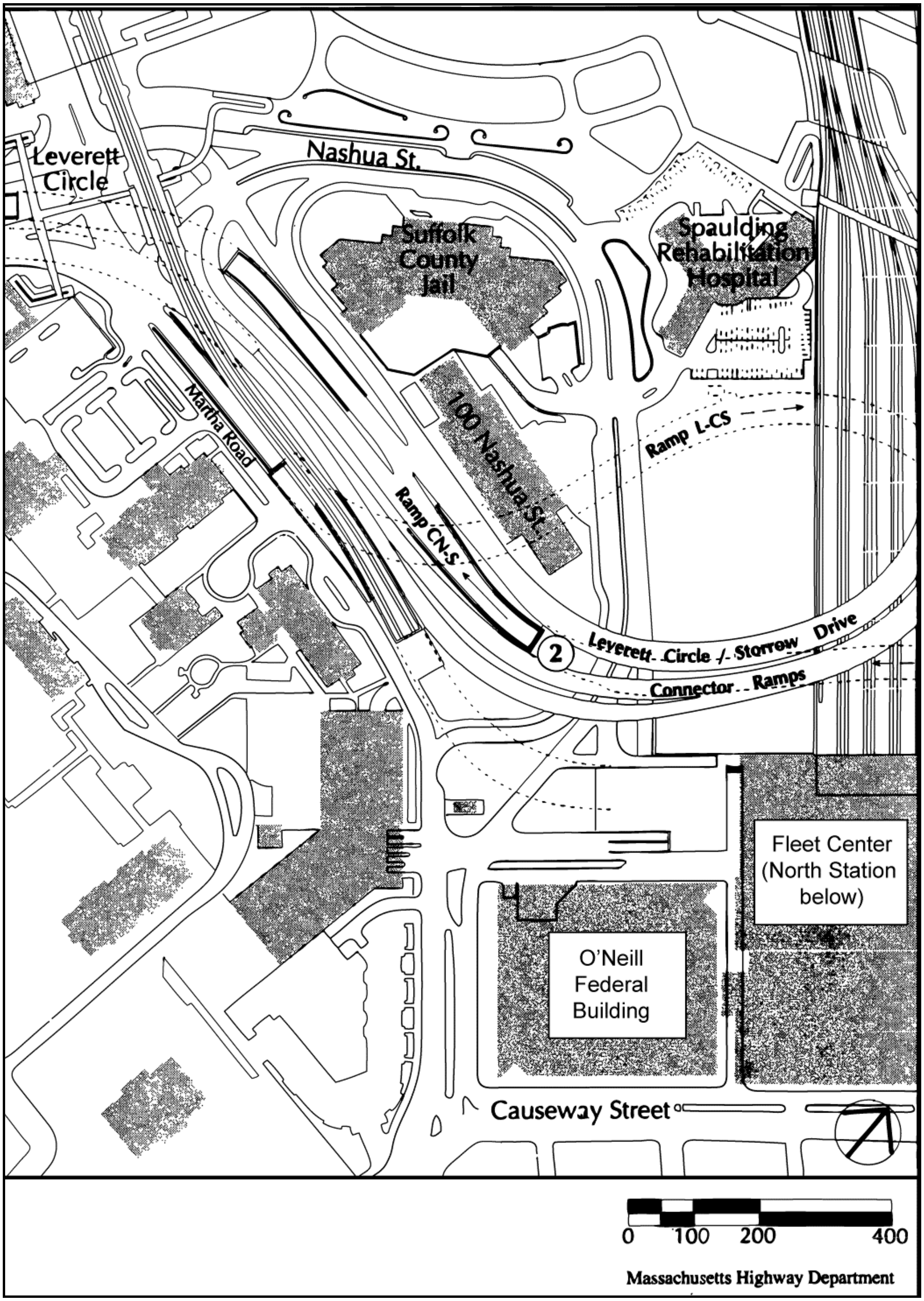


FIGURE 1-14: LOCATIONS OF RAMP PORTALS 4 (ST-CN) AND 5 (ST-SA)

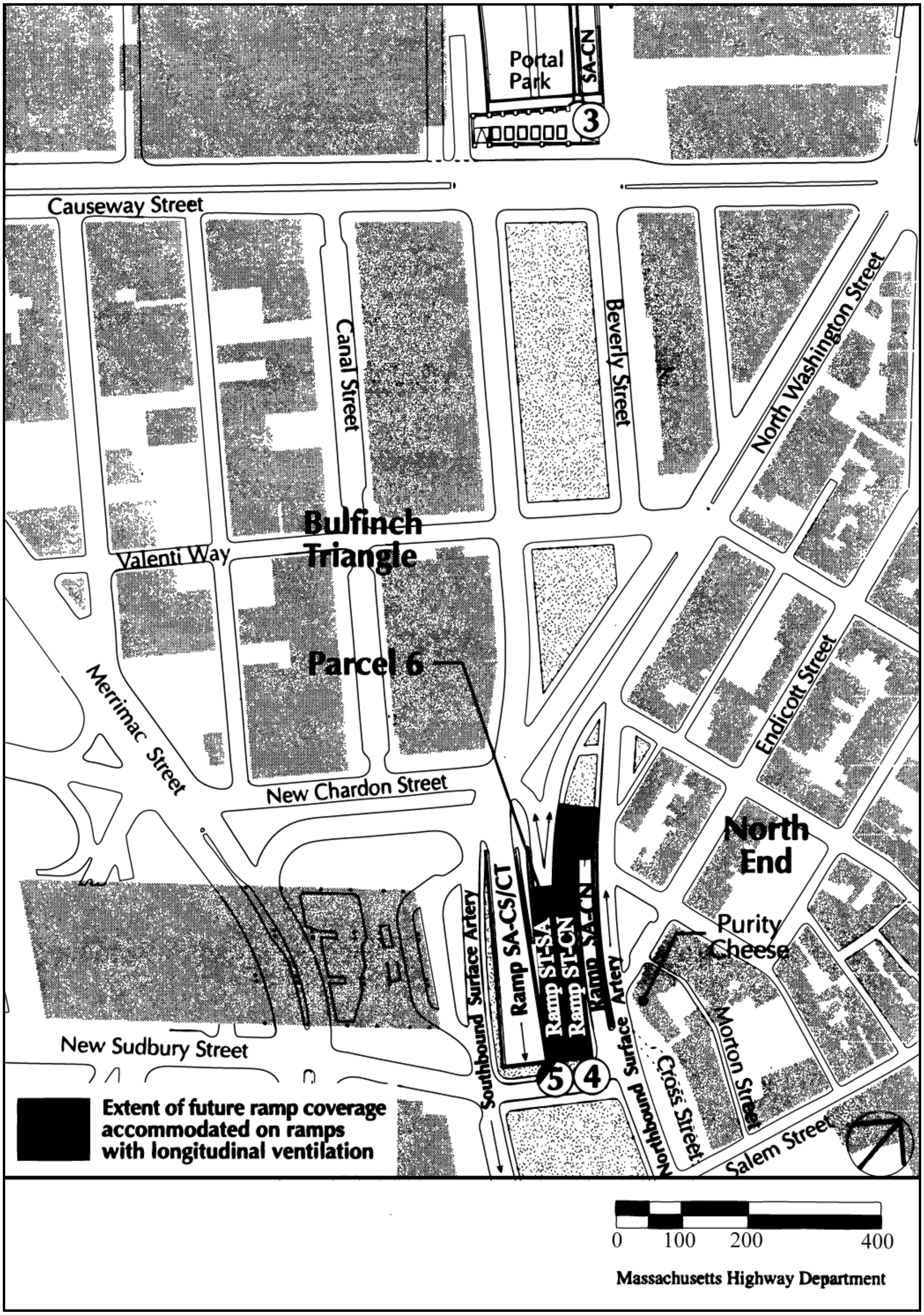


FIGURE 1-15: LOCATIONS OF RAMP PORTAL 6 (CS-SA)

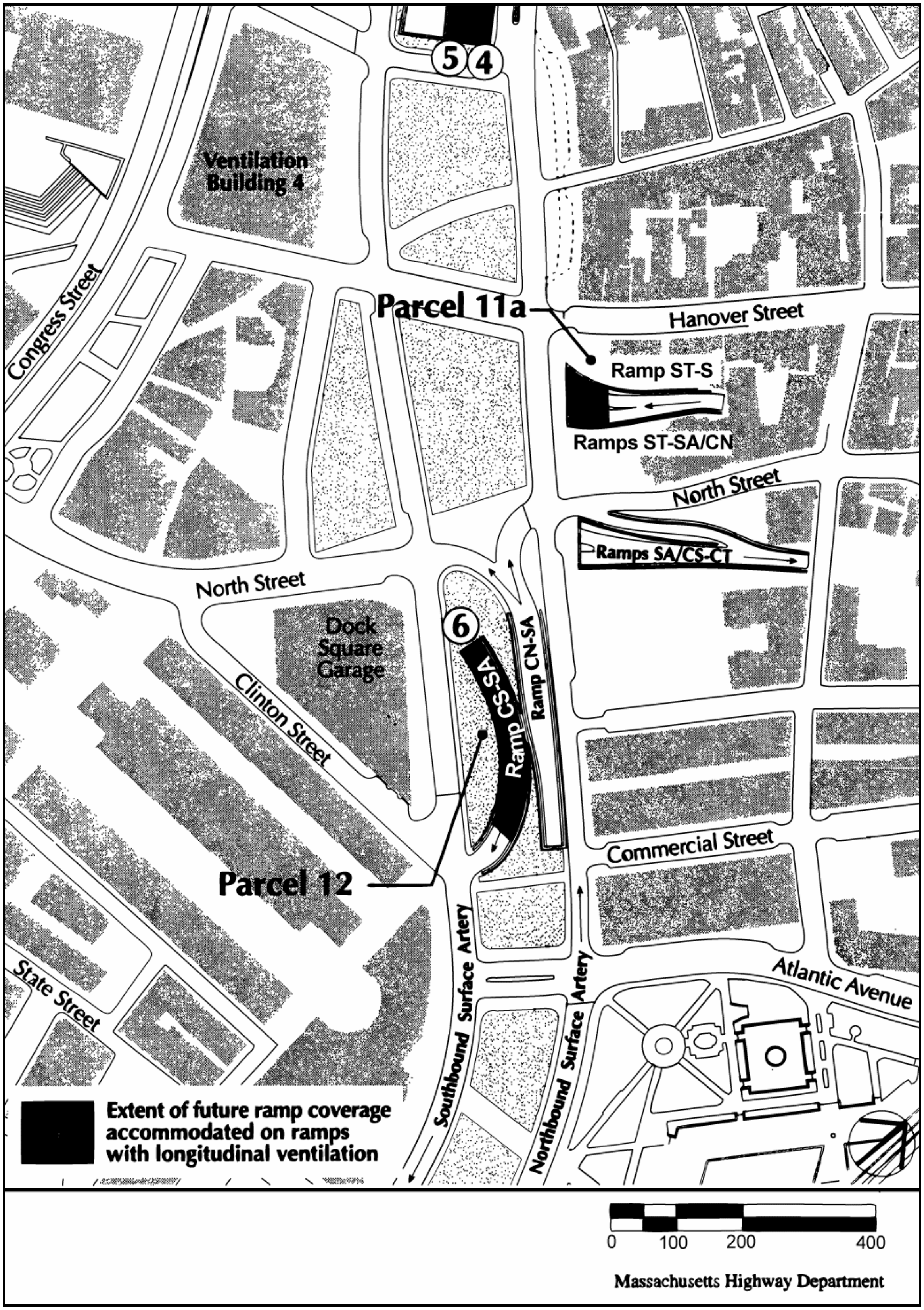


FIGURE 1-16: LOCATION OF RAMP PORTAL 7 (CS-P)

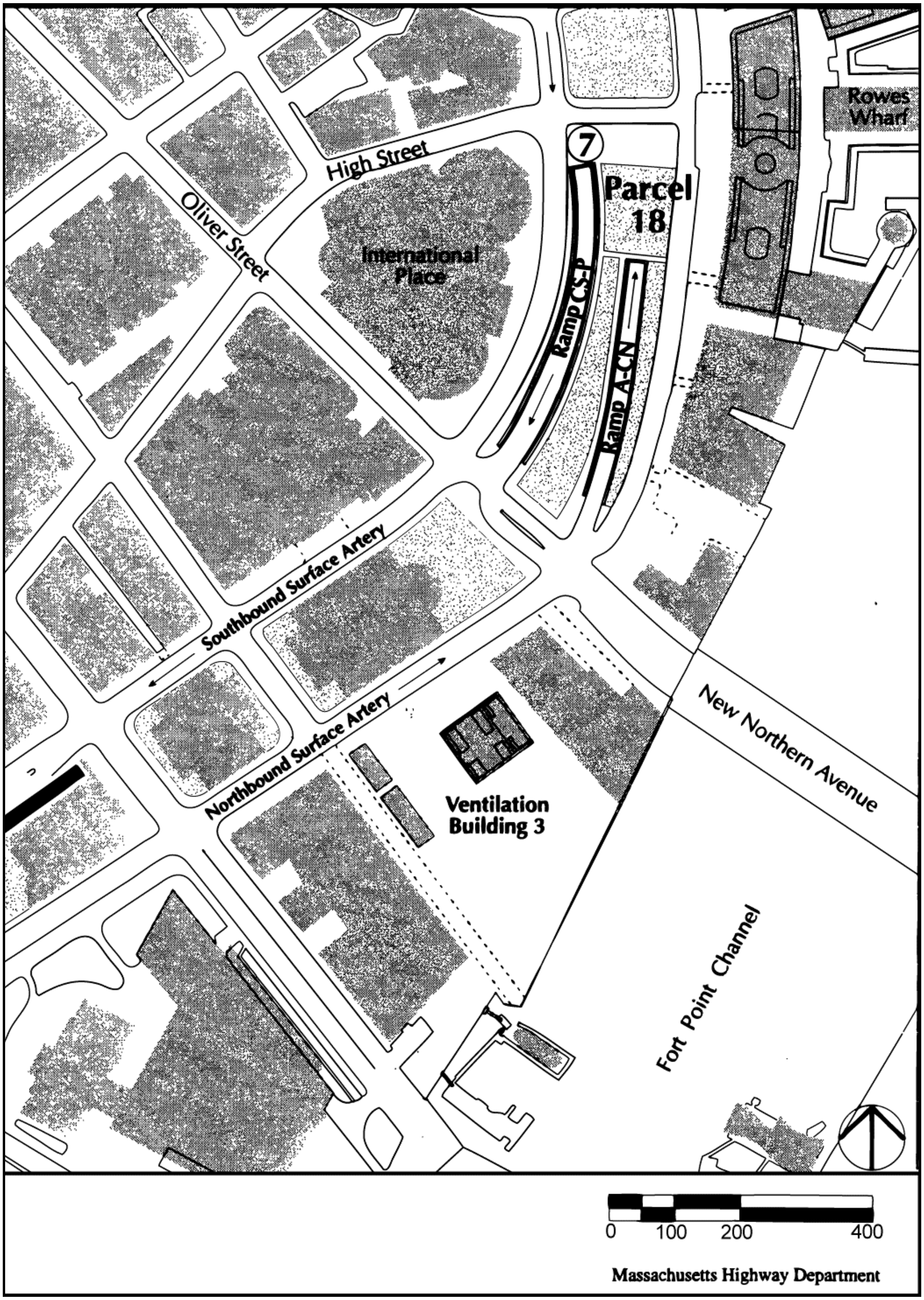
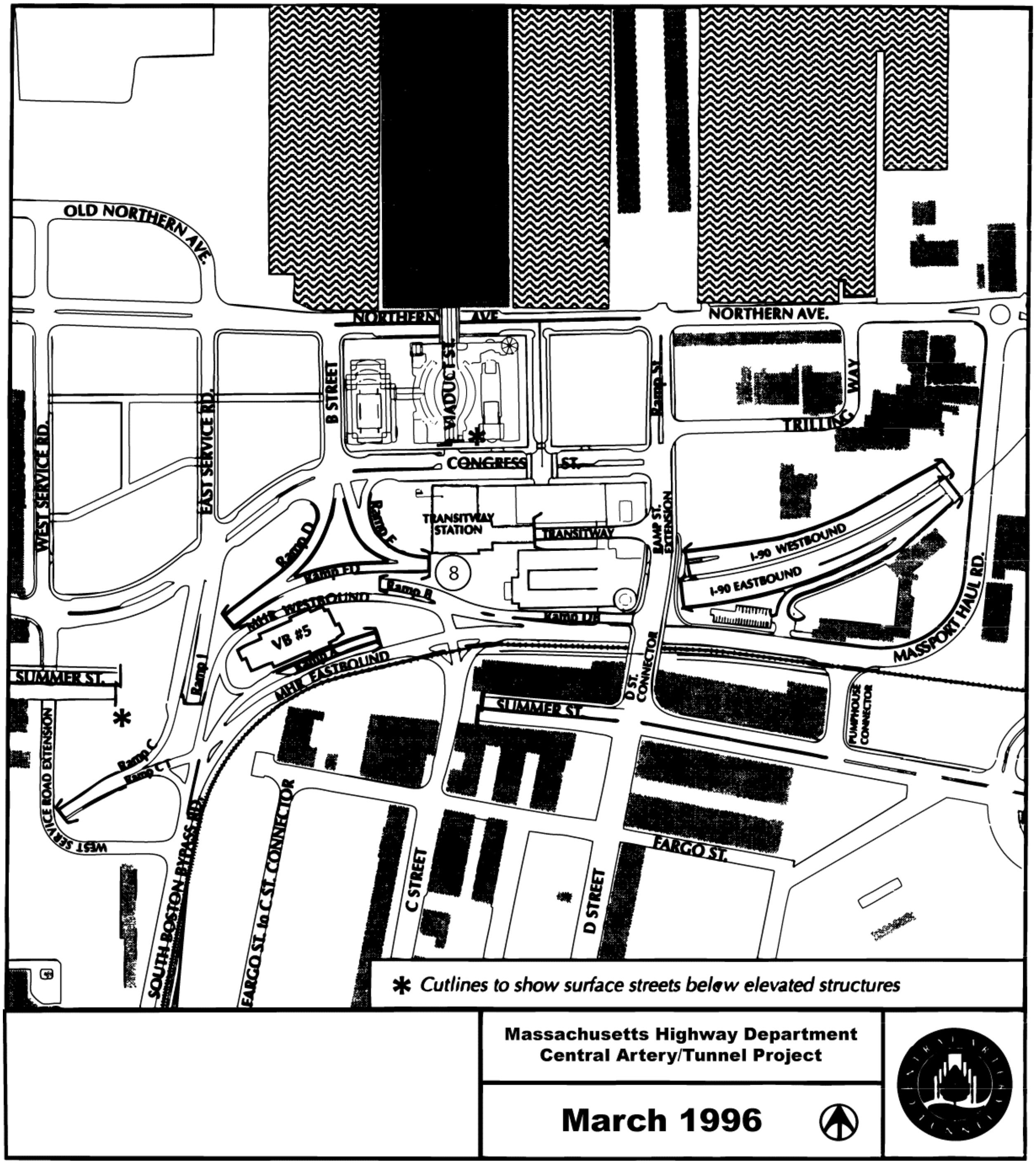


FIGURE 1-17: LOCATION OF RAMP PORTAL 8 (F)



1.2 FEASIBLE EMISSION CONTROL TECHNOLOGIES

The tunnel exhaust air contains pollutants from motor vehicles including carbon monoxide (CO), nitrogen oxides (NO_x), non-methane hydrocarbons (NMHC) and particulate matter (PM).

NMHC refers to any hydrocarbon species other than methane and, for the purpose of characterizing the ozone forming potential of organic emissions from automobiles, is used interchangeably with volatile organic compounds (VOC) and non-methane organic gases (NMOG). The term VOC is used in this document.

The tunnel ventilation systems introduce and circulate fresh ambient air into the tunnels, and remove the mixture of vehicular exhaust and intake air from the tunnels through the exhaust stacks.

Ventilation building (VB) emissions control technology reviews were performed in 1991, 1995 and subsequently updated in 2004. An extensive investigation, conducted as part of these reviews revealed that ventilation was the predominant method of tunnel (inside and outside) air quality control employed in the U.S. and around the world. All three studies concluded that there were no feasible control techniques available that would result in a net reduction of the tunnel exhaust air pollutant emissions.

The use of electrostatic precipitator systems (ESPs) has been proven to be an effective method for controlling particulate emissions, especially for long tunnels that have relatively high in-tunnel particulate concentrations. Roadway tunnels equipped with ESPs in Europe and Japan are mostly those that are relatively long and have poor in-tunnel visibility caused by heavy-duty diesel truck traffic (i.e., large PM emission sources). By comparison, the CA/T tunnels are relatively short and have a lower volume of diesel truck traffic. Therefore, the installation of ESPs for the CA/T Project probably would not result in significant decreases in PM concentrations in the tunnel exhaust air.

Several methods of controlling gaseous emissions from tunnel exhausts are in various stages of development. However, these methods have not yet been tested or applied to situations with very low concentration levels such as in the exhaust air of the CA/T tunnels. The extremely high flow and the very low concentration levels of pollutants in the exhaust air proved to be the two greatest impediments to the practical application of these control techniques. Low concentrations and large flow rates would have necessitated unreasonably large control equipment sizes, long treatment times, and the use of large quantities of reagents and catalysts with the consequent generation of large amounts of waste and the need for its disposal. More importantly, the energy (heat and power) requirements of the control techniques would have resulted in fuel consumption and additional emissions of criteria pollutants (e.g., CO, NO_x, PM, SO_2) and non-criteria pollutants (e.g., SO_3, greenhouse gases such as CO_2) that far exceed the original uncontrolled emission rates due to vehicle exhausts alone.

In addition, the emission data collected inside the CA/T tunnel (and summarized in this report) indicates that safe in-tunnel air quality has been well maintained. Likewise, the mathematical and physical modeling conducted for this project has demonstrated that the applicable ambient air quality standards will be met using the current ventilation system design.

1.3 EXPECTED TUNNEL OPERATING CONDITIONS

The CA/T Project's tunnel ventilation systems are controlled and monitored at the MTA OCC in South Boston. From this facility, tunnel operators are assigned geographical areas of responsibility for oversight of all traffic management and support systems operation. Ventilation system control from this location may be either manual—allowing the operator to make specific adjustments—or automatic via a central computer-based tunnel air quality algorithm or time-of-day histogram. In addition, each of the tunnel ventilation systems may be controlled from the local ventilation facility.

The system at each ventilation zone is normally operated in what is called a balanced mode; equal amount of supply and exhaust air to keep the system in a neutral pressure. Only in the case of emergencies will the system be operated in an unbalanced condition (i.e., over exhaust mode).

1.3.1 During Normal Operations

During daily normal traffic operating conditions, the tunnel ventilation system is operated to maintain safe air quality and visibility within the tunnels. CO levels resulting from vehicle emissions are continuously monitored throughout all Project tunnels.

The ventilation control CO monitoring system is operated independent of the CEM system described in Part II of this document. The CEM system is used to monitor compliance with the ambient air quality standards while CO monitoring system is used to operate the ventilation fans, and it does not log historical CO levels.

Real time values from each CO monitor are averaged by the OCC central computer system and reported on a per ventilation zone basis. Any exceedance of preset alert levels within a ventilation zone triggers an audible alarm to the operator and a banner display on the monitoring console provides specific data as to actual concentrations, trend and location. When controlled manually, the operator is then able to make any necessary adjustments to the ventilation zones in that particular tunnel area to restore safe air quality to the tunnel. Ventilation system adjustments might also be made during normal traffic operation when necessary to restore visibility that may be degraded due to heavy fog or dust conditions.

1.3.2 During Emergencies

The tunnel ventilation systems have been pre-programmed to operate in the most effective modes for controlling smoke and heat in the case of a vehicle fire. The programming is based on system simulation modeling of severe fire conditions to determine the most effective way to achieve critical air velocity for smoke dissipation at all locations. If a fire occurs within any of the CA/T tunnels, the OCC operator would then bring up the ventilation system emergency operating matrix on his monitor and simply “click” on the column titled “fire location.” The central computer will then operate all necessary ventilation systems in their proper modes for securing as safe an environment as possible at the site of the fire.

During these fire emergency situations it is MTA understanding based on discussions with Mass DEP that the 310CMR 7.38(2)(a) and (b) criteria would not apply based on a need to protect public safety.

1.4 VENTILATION SYSTEM PHYSICAL PROPERTIES

The ventilation system includes:

- A very large and complex network of supply air ducts located underneath the roadway pavement (or on the side walls in some downtown tunnel sections) to deliver supply air from the supply fans to each segment of the tunnel network.
- Exhaust plenums located over the tunnel ceiling (or on the side walls in the some downtown tunnel sections) to extract the exhaust air to exhaust fans located in the VBs.
- The supply and exhaust fans of each VB, the DST air intake structure and two reversible fan chambers.
- The jets fans on each longitudinally ventilated ramp.
- The OCC building, and extensive ancillary equipment which provides power and controls to the entire ventilation system.
- The backup power system.

1.4.1 Ventilation Building Dimensions and Ventilation Capacities

The locations of the VBs are provided in Figures 1-5 through 1-10. Each VB is a large structure with their largest part located underground. It includes a group of stacks at a uniform height, Table 1-1 provides the VB and exhaust stack heights above grade.

TABLE 1-1: VENTILATION BUILDING AND EXHAUST STACK HEIGHTS

VB	Heights of Buildings and Stacks Above Grade (Feet)	
	Building Roof	**Stacks**
1	82	121
3	239	278
4	80	131
5	117	178
6	60	91
7	72	108

As stated in Section 1.2, the tunnel ventilation system was designed with a supply air capacity of 65 cfm per lane-foot of tunnel, and an exhaust capacity of 100 cfm per lane-foot of tunnel. The variable speed fans can be operated at different steps (depending on the level of air flow delivered). The supply fans vary from step 1 to 6, and the exhaust fans from step 1 to 8. This means that only steps 1 to 6 are required to operate the system in a balanced mode (supply equals exhaust), while steps 7 and 8 are used in cases of emergency and fire conditions. Table 1-2 provides the total exhaust capacity of each ventilation zone and the same capacity at each operating step. Figure 1-18 provides a view of a supply fan at VB 7 with the CO and PM_{10} monitoring unit.

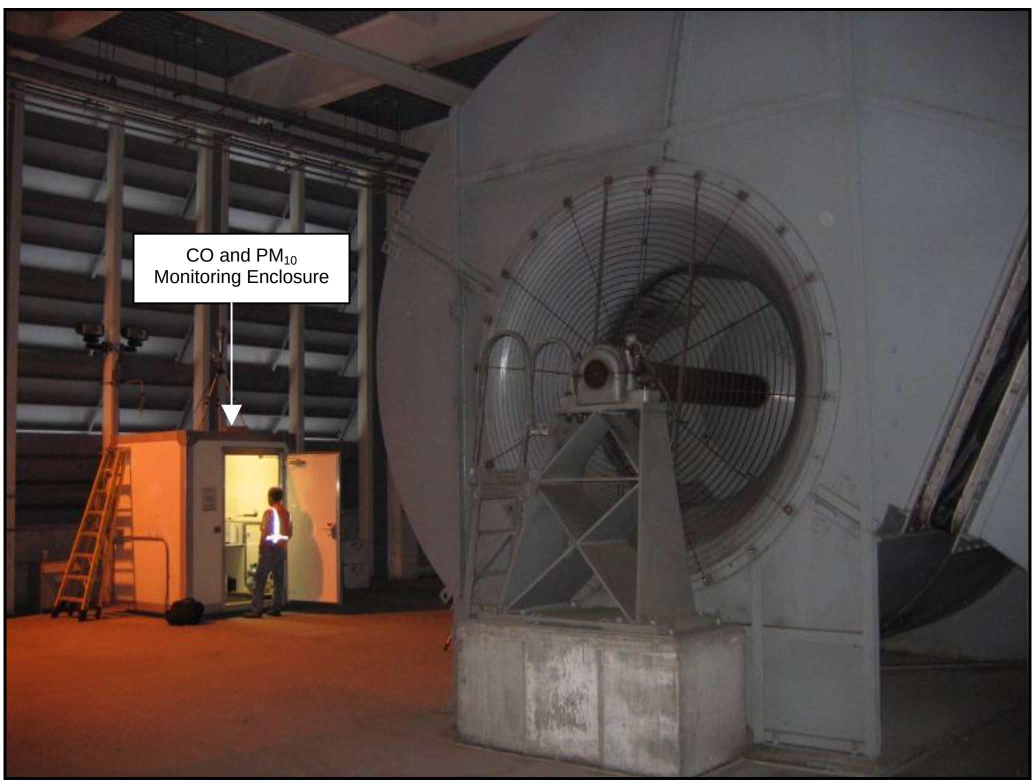


FIGURE 1-18: SUPPLY FAN AT VB 7 AIR INTAKE FLOOR

TABLE 1-2: VENTILATION BUILDINGS EXHAUST CAPACITY FOR VARYING STEPS

Ventilation Building	Ventilation Zone	Total Exhaust Capacity (CFM)	Exhaust Capacity Step 1 (CFM)	Exhaust Capacity Step 2 (CFM)	Exhaust Capacity Step 3 (CFM)	Exhaust Capacity Step 4 (CFM)	Exhaust Capacity Step 5 (CFM)	Exhaust Capacity Step 6 (CFM)
3	SB-1	1,070,000	139,100	246,100	342,400	449,400	556,400	695,500
3	NB-1	1,258,150	163,560	289,375	402,608	528,423	654,238	817,798
3	NB-2	1,139,000	148,070	261,970	364,480	478,380	592,280	740,350
4	SB-2	949,000	123,370	218,270	303,680	398,580	493,480	616,850
4	SB-3	1,130,500	146,965	260,015	361,760	474,810	587,860	734,825
4	NB-3	885,000	115,050	203,550	283,200	371,700	460,200	575,250
4	NB-4	809,000	105,170	186,070	258,880	339,780	420,680	525,850
1	SAT-Ramp D-E1	343,000	44,590	78,890	109,760	144,060	178,360	222,950
1	SAT-WB-E1	691,200	89,856	158,976	221,184	290,304	359,424	449,280
1	SAT-EB-E1	563,640	73,273	129,637	180,365	236,729	293,093	366,366
1	SAT-Ramp L/HOV-E1	941,000	122,330	216,430	301,120	395,220	489,320	611,650
5	SAT-WB-E2	1,040,000	135,200	239,200	332,800	436,800	540,800	676,000
5	SAT-WB-E3	393,000	51,090	90,390	125,760	165,060	204,360	255,450
5	SAT-EB-E2	1,112,000	144,560	255,760	355,840	467,040	578,240	722,800
5	SAT-EB-E3	558,000	72,540	128,340	178,560	234,360	290,160	362,700
6	Eastbound Zone 1	900,000	117,000	207,000	288,000	378,000	468,000	585,000
6	Westbound Zone 1	900,000	117,000	207,000	288,000	378,000	468,000	585,000
7	Eastbound Zone 2	822,000	106,860	189,060	263,040	345,240	427,440	534,300
7	Westbound Zone 2	693,000	90,090	159,390	221,760	291,060	360,360	450,450
7	Eastbound Zone 3	452,000	58,760	103,960	144,640	189,840	235,040	293,800
7	Westbound Zone 3	609,000	79,170	140,070	194,880	255,780	316,680	395,850
7	T-A/D	583,000	75,790	134,090	186,560	244,860	303,160	378,950

Notes:

Step 1 = 13% of Exhaust Capacity
Step 2 = 23% of Exhaust Capacity
Step 3 = 32% of Exhaust Capacity
Step 4 = 42% of Exhaust Capacity
Step 5 = 52% of Exhaust Capacity
Step 6 = 65% of Exhaust Capacity
Step 6 is the highest level for supply-exhaust in a balanced mode.
T-A/D - I-90 to Logon International Airport (Terminal -Arrival/Departure)

1.4.2 Longitudinally Ventilated Tunnels Dimensions and Ventilation Capacities

The plume of exhaust air that comes out of an exit portal in the wake of exiting vehicles maintains its integrity for a distance downstream of the exit portal due to the momentum created by the moving cars. This distance depends on the geometry of the roadway after the tunnel exit, the traffic flow characteristics, such as speed and density, meteorological conditions (wind direction), and other factors affecting the turbulence of the plume.

The dimensions, number of lanes and mechanical ventilation capacities of the DST and the eight longitudinally ventilated ramps exit portals are provided in Table 1-3. Figure 1-19 provides a view of a side-mounted jet fan.

TABLE 1-3: LONGITUDINAL VENTILATION TUNNEL SECTION DIMENSIONS AND MECHANICAL VENTILATION CAPACITIES

Portal No	Ramps/Scenario	Ramp Length (ft)	Number of Lanes	Total Length (lane-ft)	Mechanical Airflow Rates (KCFM) Supply Air	Min Jet Fan	Max Jet Fan
DST I-93a	DST Existing Portal	2400	4	9600	400	NA	NA
DST I-93b	DST Relocated Portal	2700	4	10800	400	NA	NA
DST I-90	I-90 Collector	2700	2	5400	200	NA	NA
1	LC-S	1020	2/1	1950	NA	197	393
2	CN-S	2000	2	4000	260	NA	NA
3a	SA-CN	1130	2	2260	NA	225	318
3b	SA-CN (with parcel 6)	2000	2/1	3000	NA	359	508
4	ST-CN	600	1	600	NA	232	328
5a	ST-SA	600	1	600	NA	232	328
5b	ST-SA (with parcel 6)	1000	1	1000	NA	130	260
6a	CS-SA	480	1	480	31	NA	NA
6b	CS-SA (with parcel 12)	780	1	780	51	NA	NA
7	CS-P	740	2	1480	96	NA	NA
8	F	700	1	700	NA	130	260

Notes: The relocated DST portal extends the DST tunnel approximately 300 feet south when development of parcel 25 is built. The DST supply capacity does not include the installed ventilation capacity of the three reversible fan chambers which operate in exhaust mode for emergency conditions.

KCFM – thousands cfm

FIGURE 1-19: JET FAN AT LONGITUDINALLY VENTILATION RAMP

The air flows at the exit portals are very dependant of the traffic characteristics such as vehicle classification, density and speed at any given time.

In order to provide an indication of the airflows generated by the traffic flows and the available mechanical ventilation that can be delivered by the air supply and jet fans, Table 1-14 summarizes the air flows at each portal as they have been estimated in support of the air quality evaluation for the *Notice of Project Change (NPC)/Environmental Reevaluation (ER) for the Implementation of Longitudinal Ventilation in the Area North of Causeway Street and Central Area, October 1996* (1996 Longitudinal Ventilation NPC/ER), and the DST final report *Air Quality Study Dewey Square Portal Boston, Massachusetts*, prepared by RWDI, January 2006.

TABLE 1-4: TRAFFIC VOLUMES, SPEEDS AND AIR FLOW RATES FOR DST AND EIGHT LONGITUDINALLY VENTILATED RAMPS

		Peak Hour			Eight Hour		
Portal No	Ramps/Scenario	Flow Rate	Traffic Volume	Traffic Speed	Flow Rate	Traffic Volume	Traffic Speed
		cfm	veh/hr	mph	cfm	veh/hr	mph
DST I-93a	DST Existing Portal	746,000	4,580	20	1,140,000	3,800	44
DST I-93b	DST Relocated Portal	772,000	4,580	20	1,220,000	3,800	44
DST I-90	I-90 Collector	592,000	3,140	27	585,000	2,650	28
1	LC-S	183,420	2,068	8	248,460	1,839	13
2	CN-S	549,440	2,997	20	610,900	2,015	26
3a	SA-CN	345,060	2,204	27	339,400	1,756	29
3b	SA-CN (with parcel 6)	382,880	2,204	27	402,500	1,756	29
4	ST-CN	130,380	166	30	160,920	350	29
5a	ST-SA	169,740	1489	20	180,150	1187	26
5b	ST-SA (with parcel 6)	208,730	1489	20	208,070	1187	26
6a	CS-SA	265,000	1,904	12	273,300	875	16
6b	CS-SA (with parcel 12)	241,320	1,904	12	275,700	875	16
7	CS-P	136,150	1,559	11	81,400	1,099	15
8	F	308,450	1,929	29	281,300	1,440	30

The conditions analyzed in the wind tunnel tests include the partial and full development conditions. The DST airflows provided represent a combination of traffic induced piston effect and the AIS operating at 50% capacity. The ramps airflows are only the result of piston action. It is worth noting the differences in the airflows between the peak and eight hour scenarios and the effect of the traffic speeds on such airflows.

2 DETERMINATION OF EMISSION LIMITS

Regulations promulgated by Mass DEP effective January 18, 1991 entitled “Certification of Tunnel Ventilation Systems in the Metropolitan Boston Air Pollution District”, 310 CMR 7.38 (sometimes hereinafter referred to as the “Vent Cert Regulations”) apply to the construction and operation of any tunnel ventilation system for highway projects constructed after January 1, 1991 including but not limited to the CA/T Project.

2.1 PROJECT PRECONSTRUCTION CERTIFICATION ACCEPTANCE RECORD

310 CMR 7.38(2) "Pre-Construction Certification" states that no person shall construct a tunnel ventilation system and project roadway subject to 310 CMR 7.00 without first certifying to Mass DEP, (and receiving Mass DEP's written acceptance of that certification), that the operation of any tunnel ventilation system, project roadway and roadway networks will not cause a violation of certain air quality standards, guidelines and criteria specified in the Vent Cert Regulation.

On February 20, 1991, to comply with the provisions of the Vent Cert Regulation, the Massachusetts Department of Public Works, now the MHD submitted to Mass DEP a Pre-Construction Certification of the Tunnel Ventilation System for the CA/T Project (Pre-Construction Certification). The Pre-Construction Certification was found to be administratively complete by Mass DEP on March 27, 1991. On May 7, 1991, Mass DEP conducted a public hearing on the Pre-Construction Certification to receive comments pursuant to 310 CMR 7.38(11). After review of the information set forth in the Pre-Construction Certification and consideration of information presented at the public hearing and during the public comment process, Mass DEP accepted the Pre-Construction Certification subject to conditions set forth in the decision document dated July 8, 1991 entitled *Conditional Acceptance of Pre-Construction Certification of the Central Artery/Third Harbor Tunnel Project* (Conditional Acceptance). Mass DEP determined that the mitigation measures set forth in the Conditional Acceptance were necessary to mitigate potential adverse air quality impacts from the CA/T Project and to meet the criteria set forth in the Vent Cert Regulation for project certification. The mitigation measures set forth in the Conditional Acceptance included Public Transportation Measures, Measures to Increase Commuter Rail Ridership, Water Transportation Measures, Transportation Management Measures and a High Occupancy Vehicle (HOV) Program.

On September 10, 1992 MHD submitted an amendment to the Pre-Construction Certification to update technical information based on design refinements to the CA/T Project and to provide a basis for Mass DEP to clarify the requirements of Section VI of the 1991 Technical Support Document, (that was submitted with and in support of the Pre-Construction Certification) to provide consistency with the 1991 Transit Regulations, 310 CMR 7.36, and HOV Regulations, 310 CMR 7.37, that were adopted by Mass DEP in December 1991.

On January 7, 1999 the MTA, on behalf of MHD, submitted to Mass DEP for its review and acceptance pursuant to the Vent Cert Regulation an amendment to the Pre-Construction Certification. The 1999 Amendment to the Pre-Construction (Amended Pre-Construction Certification) superseded the 1992 amendment. Submitted with and in support of the Amended Pre-Construction Certification was a 1999 Technical Support Document that updated, (but did not replace), the 1991 Technical Support Document to reflect analyses performed in connection with design changes to the CA/T Project since 1991 that had been reviewed through the Massachusetts Environmental Policy Act (MEPA) and that had then been incorporated as part of the CA/T Project design. In addition, the 1999 Technical Support Document updated Section VI, of the 1991 Technical Support Document on "Methods to Minimize Miles Traveled" to reflect the current status of the demand reduction strategies and transportation control measures included in the planning and implementation programs of the Executive Office of Transportation and Construction (EOTC), now Executive Office of Transportation (EOT).

The Amended Pre-Construction Certification was found to be administratively complete by Mass DEP on February 26, 1999. On March 30, 1999 Mass DEP conducted a public hearing on the Amended Pre-Construction Certification to receive comments pursuant to 310 CMR 7.38(11). Mass DEP issued proposed decision documents on the Amended Pre-Construction Certification on April 29, 1999 and conducted a public hearing on those proposed decisions on May 20, 1999. After review of the information submitted by MTA, MHD and EOTC and the information presented at the public hearings and during the public comment period, Mass DEP accepted the Amended Pre-Construction Certification subject to certain conditions in a document dated September 1, 2000 entitled "DEP Determination on the Amended Pre-Construction Certification of the CA/T Project under 310 CMR 7.38" (DEP Determination). Among those conditions was an Administrative Consent Order (ACO) by and between Mass DEP and EOTC, also dated September 1, 2000 that was incorporated by reference into and thereby made part of the Mass DEP Determination. The ACO has been twice amended; Amendment #1 on May 23, 2002 and Amendment #2 on January 26, 2005.

The Pre-Construction Certification and the Amended Pre-Construction Certification required a number of mitigation measures designed to " ... mitigate potential adverse air quality impacts from the CA/T Project and to meet the criteria for project certification." To address delays in certain mitigation measures, the ACO and amendments to the ACO required additional measures to be implemented to provide reductions in vehicles miles traveled and emissions during the delay of the required mitigation measure.

2.2 MASS DEP REGULATORY REQUIREMENTS FOR OPERATING CERTIFICATIONS

As discussed in Section 2.1, the Ventilation Certification Regulations required the issuance by the constructor, MHD of a Pre-Construction Certification; and subsequently by the operator, MTA of an Operating Certification. As part of the Operating Certification requirements, the MTA must demonstrate that the tunnel ventilation system when operated in accordance with its design standard operation and maintenance procedures would not:

- Cause or exacerbate a violation of any National Ambient Air Quality Standard (NAAQS), or a Massachusetts Ambient Air Quality Standard;
- Cause or exacerbate a violation of the Mass DEP's one hour ambient nitrogen dioxide (NO_2) guideline of 320 μ/m^3; or
- Result in an actual or projected increase in the total amount of non-methane hydrocarbons (referred as VOC in this document) measured within the Project area when compared with the No-Build alternative.

MTA should also demonstrate that the operation of the tunnel ventilation system is in accordance with the criteria set forth in the Pre-Construction Certification accepted by Mass DEP. The Ventilation Certification Regulation provides that this demonstration shall be based on actual measured emissions and traffic data.

It is worth noting that based on discussion with Mass DEP it is MTA understanding that the 310 CMR 7.38(2) requirements regarding compliance with the applicable ambient air quality standards and the State Policy guideline for nitrogen dioxide would not apply during emergency conditions (i.e., tunnel fires).

In support of the Operating Certification, an air quality compliance demonstration was performed. However, MTA is required to establish emission limits for the tunnel ventilation system such that operation of the CA/T ventilation system below these limits would not cause or exacerbate a violation of any applicable ambient standards. Actual CA/T operating experience and measured in-tunnel pollutant concentration levels thus far are taken into consideration in determining these emission limits.

During the past five years, a technical working group representing the CA/T Project and Mass DEP, have been meeting on a quarterly basis to discuss the methodologies for determination of the CA/T tunnel ventilation system emission limits, continuous emission monitoring and demonstration of ambient air quality compliance.

The Project Compliance Monitoring Program during operation includes CO continuous emission monitoring at the plenum of each ventilation zone, and PM_{10} continuous emission monitoring at four ventilation zones which represents the ventilation zones with the largest potential for high PM_{10} levels at the mainline tunnel exhaust points. Due to the limited space available and other technical impediments inside the ramps, instead of in-tunnel monitoring it was agreed with Mass DEP that a permanent PM_{10} monitor will be installed outside exit Ramp CS-SA to determine if the emissions from the longitudinally ventilated ramps could have the potential to cause high PM_{10} levels in the adjacent areas. NO_x levels at each CEM monitoring location will be determined as a function of the hourly monitored CO levels. The monitoring results and the calculated NO_x levels are compared to their predetermined emission limits for compliance assessment.

For the volatile organic pollutants (VOC) the MTA is required to demonstrate that the tunnel ventilation system when operated in accordance with its design, standard operation, and maintenance procedures would not result in an actual or projected increase in the total amount of VOC measured within the Project area compared to the No-Build alternative. The 2005 regional VOC emissions for the area affected by the CA/T Project Build scenarios are compared to the No-Build scenario (budget) and will then be used as a limit, which is not to be exceeded in the future years for compliance demonstration purposes.

2.3 ACCEPTANCE OF CONCENTRATION–BASED EMISSION LIMITS

It was established by the MTA-Mass DEP technical working group and concurred by Mass DEP (Mass DEP letter dated April 16, 2002) that the emission limits for CO, NO_x and PM_{10} are determined as concentration-based levels (i.e., ppm or $\mu g/m^3$) in lieu of mass-based (i.e., g/s). The rational for the concentration based emission limits, which meet the requirements of 310 CMR 7.38, is briefly discussed as follows:

Vehicular emissions depend on the number, type and conditions of the vehicles and their traveling speeds. Although the MTA is the Owner and Operator of the CA/T tunnel ventilation system, the Project tunnels are open for general public use under normal operation conditions without exception. Therefore, the MTA has no control regarding the type and conditions of vehicles entering the tunnel and it can only manipulate the ventilation rates of the tunnel ventilation system based on traffic conditions to provide acceptable in-tunnel air for the motorists traveling the tunnels. Thus, the emission limits to be set for all three pollutants will be the maximum allowable concentrations which will ensure that the applicable ambient standards are not exceeded.

Since there are no NAAQS for VOC, emission limits for VOC cannot be established based on concentrations to be measured at a specific receptor location. As such, direct measurement or monitoring of VOC without a benchmark level to guide the operation of the ventilation system may or may not contribute to the protection of the health and welfare of the affected population. A different procedure that is based on the study area VOC budget was developed by the MTA-Mass DEP air quality working group and accepted by Mass DEP on July 30, 2002. The established VOC budget for the CA/T Build condition will then be used as the emission limit, which is not to be exceeded in the future years for compliance demonstration purposes.

2.4 TECHNICAL APPROACH

The technical approach for emission limits determination is provided in Appendix B, "Air Quality Analysis Protocol for Determination of Emission Limits as Part of the Operating Certification of the Project Ventilation Systems" of this document. The following briefly summarizes the methodology employed.

2.4.1 Relevant Pollutants

The relevant vehicular pollutants for which emission limits are developed are those established in the Ventilation Certification Regulations at 310 CMR 7.38(2), namely: Carbon Monoxide (CO), Nitrogen Oxides (NO_x), Particulate Matter (PM_{10}) and non-methane hydrocarbons (VOC).

2.4.2 Time Averaging Emission Limit for CO, NO_x, and PM_{10}

The duration of the emission limits for CO, PM_{10}, and NO_x are determined by their respective NAAQS and Mass DEP Policy Guideline Value as follows:

Duration	Pollutant	Emission Locations
1-hour and 8-hour	CO	VB exhaust plenum and longitudinally ventilated ramps
1-hour	NO_x	VB exhaust plenum and longitudinally ventilated ramps
24-hour	PM_{10}	VB exhaust plenum and vicinity of Ramp CS-SA

2.4.3 Predictive Model for NO_x Emission Estimates

NO_x emission levels are estimated based on the monitored CO emission levels using the Project-specific regression model formulation which correlates the monitored measurements of CO and NO_x. The statistical analysis performed as part of the 1997/98 and 2004 monitoring programs at the Ted Williams Tunnel (TWT) indicated that there is a good correlation between the measured CO and NO_x data.

The 1997/98 TWT Emissions Monitoring Program measured CO, NO, NO_x, total hydrocarbons (THC), and PM_{10} for a two week period every quarter from December 1996 thru December 1998 at four ventilation zones for VB 7 and two ventilation zones for VB 6. The results of more than 20,000 hourly values recorded indicated that there was a good correlation between measured levels of NO, NO_x and CO. Correlation coefficients were between 0.5 and 0.82, and linear regression models were developed to predict in-tunnel NO and NO_x levels based on measured CO levels.

At the request of Mass DEP, these regression models were refined by collecting additional data when I-90 opened for general public use to account for the difference in vehicle classification from the Early Opening Phase, and to represent the Full Opening traffic conditions.

During 2003, the MTA and Mass DEP technical working group agreed that the CO/NO_x relationship (or regression model) was to be used for the prediction of NO_x levels for emission limit determination and for demonstration of compliance with the Mass DEP one-hour NO_2 policy guideline (320 $\mu g/m^3$) as it relates to 310 CMR 7.38. The 2004 TWT monitoring program collected an additional two weeks of CO, NO_x and NO hourly data at all four ventilation zones of VB 7 every quarter (approximately 6,000 hours of measurements).

Since the 2004 monitoring data reflects the current TWT operating conditions (general traffic use and recent vehicle technology), the regression models based on the 2004 data were chosen to represent current full traffic conditions. Also, since the ambient O_3 levels are higher during summer, regression formula based on the 2004 summer data for NO_x predictions was chosen for compliance demonstration.

The CO and NO_x data collected during August 9-25, 2004 are plotted in Figure 2-1. The equation developed from this data set to be used in the modeling analysis and to estimate the hourly NO_x levels is:

$$NO_x = 0.196 + 0.124\ CO \quad (1)$$

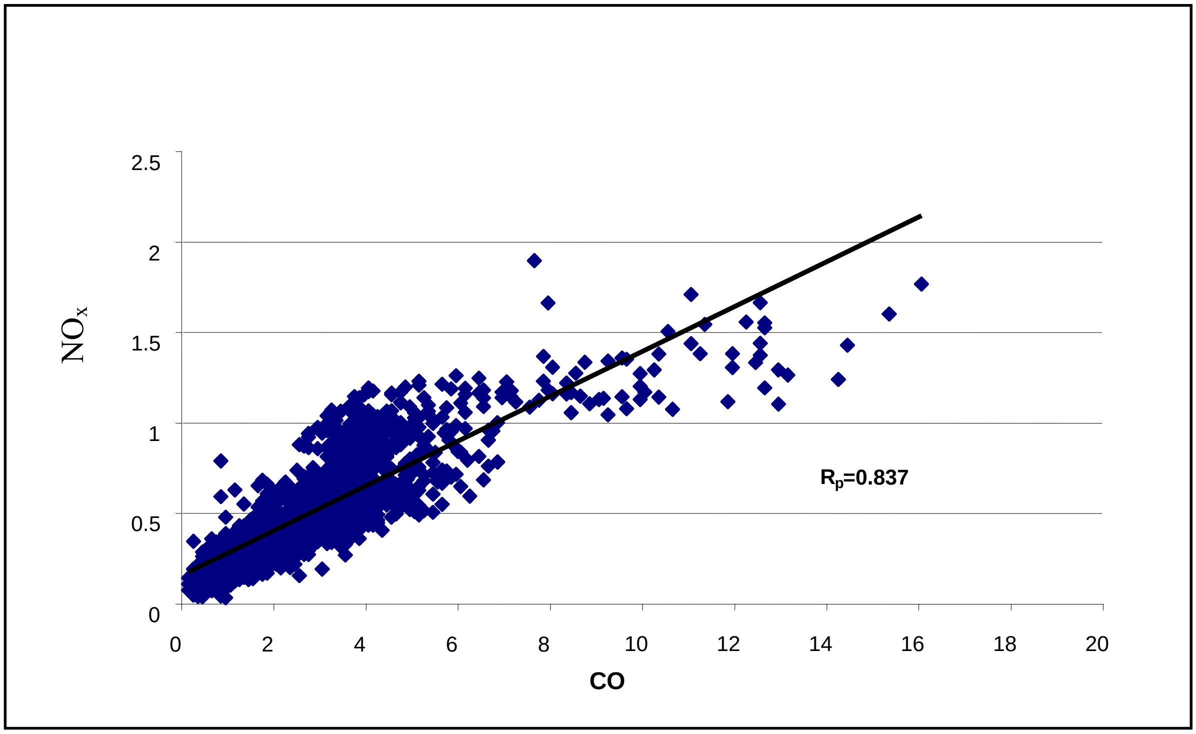
Table 2-1 presents the CO/NO_x relationship based on August 2004 measured data which were chosen to represent current conditions

TABLE 2-1: CO/NO_X RELATIONSHIP BASED ON AUGUST 2004 MEASURED DATA

CO	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	50.0	55.0	60.0	65.0	70.0
NO_x	1.44	2.06	2.68	3.30	3.92	4.54	5.16	5.78	6.40	7.02	7.64	8.26	8.88

The report titled *CA/T Ted Williams Tunnel 2004 Carbon Monoxide – Nitrogen Oxides Monitoring Program*, December 2004, includes full description of the data collection process and statistical analysis. The report was submitted to Mass DEP on January 13, 2005; and Mass DEP agreed to the use of the above equation for the compliance demonstration (Mass DEP letter March 24, 2005).

FIGURE 2-1: CO/NO_X RELATIONSHIP BASED ON MONITORED LEVELS AT THE TED WILLIAMS TUNNEL (AUGUST 2004)



2.4.4 NO_x to NO_2 Conversion

Most of the NO_x emitted by vehicles is in the form of NO. Based on the TWT's monitoring results, the average NO component ranged from 83 to 93% of emitted NO_x. NO can convert to NO_2 through chemical reactions with oxidants, namely O_3, present in the atmosphere.

The amount of NO_2 present in the atmosphere within the CA/T Project impacted areas is a combination of three different sources of NO_2:

- NO_2 directly emitted from the vehicles and released into the atmosphere through the VB and the exit portals.
- NO_2 formed from the oxidation of NO that is emitted from the vehicles and released into the atmosphere through the VBs and the exit portals.
- NO_2 present as background in the atmosphere.

The Ozone Limiting Method (OLM) that is used assumes that the reaction of NO with O_3 is the predominant pathway for conversion of NO to NO_2. For the CA/T Project, an upper limit of 81% conversion of NO to NO_2 was established in the 1990 FSEIS/R analysis, and it has been used on all CA/T air quality modeling analyses. This maximum limit includes 76% NO to NO_2 conversion, and 5% of the vehicular NO_x emitted directly as NO_2.

The total amount of NO_2 estimated at each receptor location will be calculated as follows:

For $0.81\ [NO_x] > [O_3]$, $[NO_2] = 0.05\ [NO_x] + [O_3] + [NO_2]$ background (2)

For $0.81\ [NO_x] < [O_3]$, $[NO_2] = 0.05\ [NO_x] + 0.76\ [NO_x] + [NO_2]$ background (3)

2.4.5 Representative Surface and Upper Air Meteorological Data

The most recent 5 years of surface observations collected at the Logan International Airport, Boston, MA for 2000–2004 was used in this analysis with concurrent upper air data collected at the National Weather Station in Portland, Maine. Due to proximity of these weather stations to the Project area, meteorological data collected at these locations offers the most regionally representative and readily available data base for the compliance demonstration study.

2.4.6 Attainment Status of Project Area

The Boston area, inclusive of the CA/T Project, is designated as non-attainment for 8-hour Ozone (O_3), maintenance for CO, and attainment for PM_{10} and NO_2.

2.4.7 Background Concentration Levels

Background pollutant concentrations are obtained from several Mass DEP air quality monitoring stations in the Boston area. Hourly measurements or a selected level were used depending on the types of analyses.

For the longitudinal ventilation analysis CO background levels are the years 2000 to 2004 hourly measurements at the Mass DEP Roxbury monitor at Back Bay at Harrison Avenue. For full transverse ventilation a highest second highest one hour and eight hour average concentrations from the latest three years were selected as shown in Table 2-2. The CO levels of 2.8 ppm for one-hour and 2.4 ppm for eight hours were used in the modeling.

TABLE 2-2: CO LEVELS AT ROXBURY MONITORING STATION

Year	One Hour Concentration	Eight Hour Concentration
2002	2.6	1.8
2003	4.0	2.4
2004	2.8	1.5
Selected	4.0	2.4

The NO_2 background concentrations for compliance with the Mass DEP Guidance level are comprised of the year 2000 hourly data collected at the Mass DEP Bremen Street monitor in East Boston and of years 2001 to 2004 hourly data collected at the Mass DEP Harrison Avenue monitor at Back Bay. Monitoring of the NO_2 concentration at Bremen Street was discontinued by Mass DEP in 2001. The required concurrent five years of hourly O_3 data were collected also at the Harrison Avenue Mass DEP monitoring station. The annual NO_2 background concentration was the highest of the latest three year annual averages as presented in Table 2-3.

PM_{10} background concentrations are based on data recorded for the last three years (i.e., 2002–2004) at the TEOM® station located in North End.

Table 2-4

~~Table 2-4~~ provides the highest measured levels.

TABLE 2-3: NO_2 ANNUAL LEVELS AT ROXBURY MONITORING STATION

Year	Annual Average Concentration
2002	0.0241
2003	0.0230
2004	0.0170
Summary	0.0241

TABLE 2-4: PM_{10} LEVELS AT NORTH END MONITORING STATION (μg/m^3)

Year	Total Days	24-hours			Annual Average
		1st Highest	2nd Highest	3rd Highest	
2002	208	87.6	77.5	60.6	24.0
2003	344	59	46.3	45.8	21.8
2004	288	57	54.8	47.5	22.1
Summary	840	87.6	77.5	60.6	22.6

The 24-hour background level is selected based on the total number of observations for the three years. For years 2002 through 2004 at the North End monitoring station the 24-hour background should be the third highest observation of the three year period—60.6 μg/m^3. The annual background is the annual average of the three years—22.6 μg/m^3. This follows the procedures in the *EPA PM_{10} SIP Development Guideline* (EPA-450-2-86-001). The North End station had 840 observations between 2002 and 2004. The use of the third highest is recommended by EPA if the number of observations is between 696 and 1042 (see Table 2-4).

2.4.8 Non-Methane Hydrocarbons (VOC)

Procedures developed to address the VOC requirements of 310 CMR 7.38 (4) and (2)c are as follows:

- Prepare an updated emission estimate, which compares the total amount of VOC generated by motor vehicle activity within the Project area for two scenarios including the full operation of the CA/T Project (post opening – year 2005) and a No-Build condition for the same year 2005.
- Establish an emission budget for the Project study area based on the results of the VOC evaluation for year 2005.
- Update or verify at an interval of every five years that total VOC emissions for the study area are below the established emission budget.

This process mirrors the process used in the 1990 FSEIS/R for the Preconstruction Certification, but it is based on current traffic and motor vehicle emission data instead of future projections of the Project effects on a distant future. As such it will provide a much higher level of confidence on the actual area wide effects of the CA/T Project including transit commitments which form part of the Ventilation System Certification Process.

2.5 EMISSION LIMIT DETERMINATION

Currently, peak hour traffic volumes (vehicles per hour [vph]) using the mainline tunnels range from 4,500 to 5,000 vph in each direction of I-93, and 2,300 to 2,500 vph in each direction of the TWT. These levels are between 60 to 80% of the projected year 2010 peak hour levels. The tunnel ventilation system currently is operating at Step 1 (13% of exhaust capacity) during off-peak and night hours, and Steps 2 or 3 (23% to 32% of exhaust capacity) during peak hours. Current measured CO tunnel concentrations range from 2 to 5ppm during off-peak and as high as 20 to 30ppm during peak periods.

The maximum hourly allowable emission limits (in ppm) for the VBs, DST and the specified exit ramps are determined using an iterative modeling process by increasing or decreasing the exhaust concentration in a prescribed interval.

In principle, the final emission limits are expected to be set as high as the maximum allowable levels such that when the CA/T ventilation system exhaust concentration is below this limit, it will not cause or exacerbate a violation of the applicable NAAQS and at the same time allow for traffic growth in the Project tunnels and also provide flexibility in operating the tunnel ventilation system.

2.5.1 For Full Transverse Ventilation—Ventilation Buildings

2.5.1.1 Determination of Ventilation Building Emission Impacts

The VB emission impacts are evaluated through the use of analytical models. The maximum predicted emission impacts, when added to the appropriate background pollutant concentrations are compared to the applicable ambient air quality standards or policy guideline value for compliance assessment. The entire modeling process was repeated until the maximum allowable emission limits at which ambient standards can still be attained are found. The detailed modeling procedures used for determination of the VB emission impacts and emission limits can be found in Appendix B, "Air Quality Analysis Protocol for Determination of Emission Limits as Part of the Operating Certification of the Project Ventilation Systems" of this document.

2.5.1.2 Modeling Methodology

The modeling approaches used in this study are similar to those that were used in the CA/T Project Pre-Construction Certification. The VB emission impact analysis is performed using the EPA's Industrial Source Complex–Prime Model (ISC-Prime, 2004) in conjunction with the most recent background air quality data collected at the area and five years of representative hourly meteorological data (see Section 2.4.6). Sensitive receptors such as building air intakes, operable windows, pedestrian walkways and potential receptors on proposed redevelopment projects within 2000 feet of each VB are updated to reflect the existing environment and future commercial development projection.

As discussed in Section 1, there are a total of 22 ventilation zones in the CA/T ventilation system. In general each of these ventilation zones is equipped with more than one exhaust stack and each stack is dedicated to serving one exhaust fan. Fan speeds are controlled by 8 set point steps.

In the modeling, all stacks serving one ventilation zone are group together and treated as an individual emission point. The physical center of the stacks serving the same ventilation zone is treated as the center of the source in the modeling runs. The total stack exit area is used in calculation of the equivalent stack diameter. The total flow rate is divided by the total stack exit area to obtain the equivalent stack exit velocity. A spectrum of four ventilation scenarios (based on fan steps 2, 3, 4 and 5) were selected to be modeled.

The highest predicted pollutant concentration is added to the appropriate background level to estimate their combined impact and to compare to the applicable short or long-term air quality standard.

2.5.1.3 Emission Limits Determination Methodology

The maximum hourly allowable emission limits (in ppm) for all VBs are identified using an iterative modeling process by increasing or decreasing the exhaust concentration in a specified interval.

To facilitate the selection of an initial exhaust concentration level to begin the iterative process, computer test runs were made to compare the resulting impacts of different ventilation scenarios (i.e., at fan steps 2, 3 and 4). Modeling results indicate that for a given exhaust concentration level the higher the exhaust rate becomes, the worst the impact gets. Therefore, the worse impact would be associated with the highest ventilation scenario.

Initially a spectrum of four ventilation scenarios (based on fan steps 2, 3, 4 and 5) were selected to be modeled. Based on past CA/T Project-specific operating experience, operating the tunnel at in-tunnel CO level of 70 ppm in combination with fan speed at Step 5 is a very unlikely event. Therefore, a detailed impact assessment associated with such an operating scenario is not considered

For each ventilation zone, the exhaust capacity by fan step can be found in Table 1-2. Model input data, including emission rates, exhaust flow rates, exhaust temperature, and number of fans by ventilation zone are presented in Table 2-7. The stack locations and configurations for all the VBs are depicted in Figures 2-2 through 2-7. Representative stack locations and sensitive receptors used in the modeling analysis are presented in Appendix C, "Air Quality Impact Analysis Input Data" (Tables C-3 through C-8) for each VB. Background air quality levels used in the analysis are described in Section 2.4.8.

CO Analysis

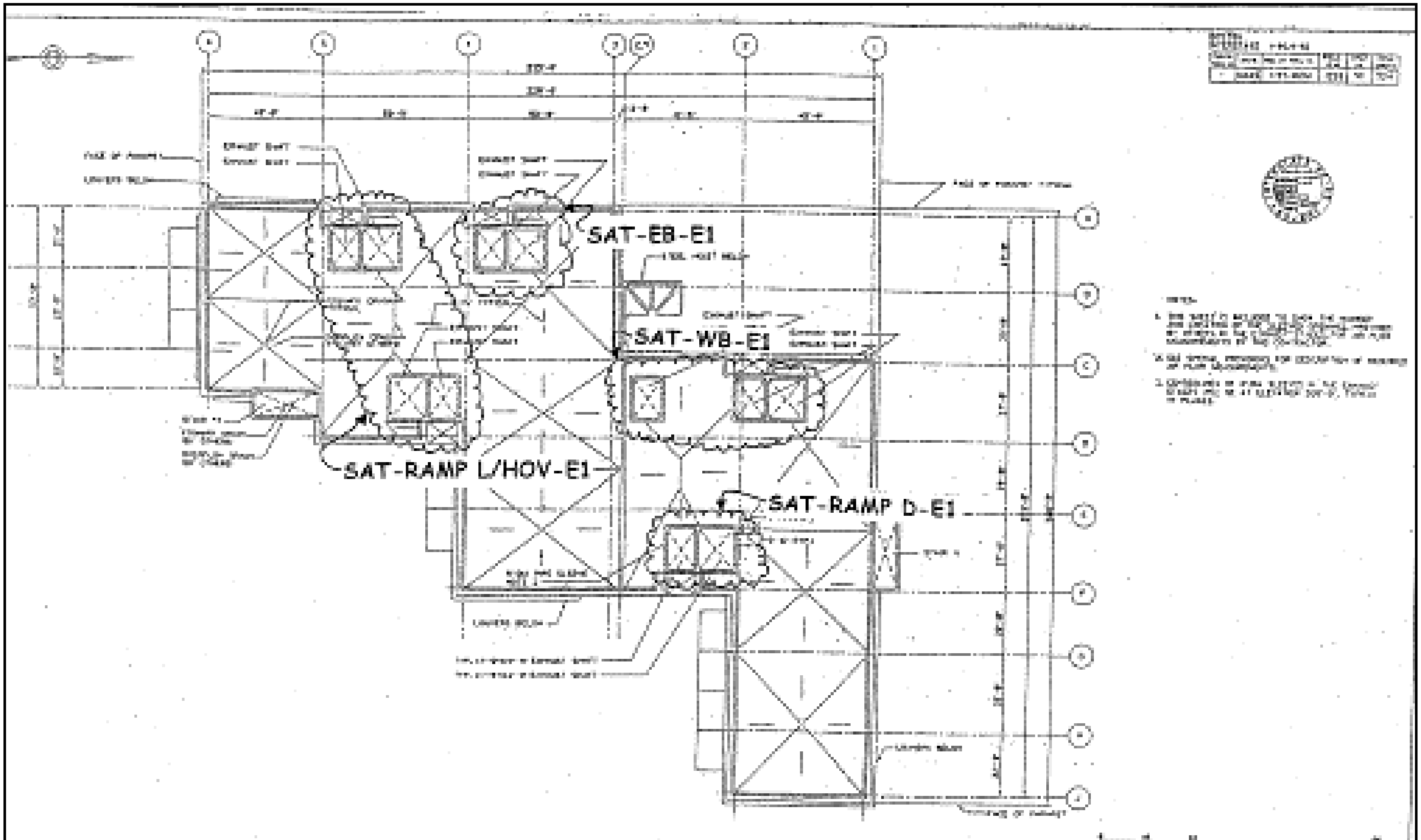
As a starting point, the exhaust CO concentration at each emission point was arbitrarily set at a much higher level (70 ppm) than the current tunnel operating conditions (20–30 ppm) to facilitate the identification of the maximum hourly allowable emission limits. This hypothetical high in-tunnel CO concentration in combination with the proposed Fan Step 4, which is equivalent to an exhaust flow rate at 42% of the total exhaust capacity, form the basis for the initial compliance test case. Results of the analysis for all VBs, as reported in Tables 2-5 and 2-6, indicate that the maximum combined impacts at receptor locations resulting from operation of each of the VBs are less than 60% of the NAAQS for CO. It is worth noting that the predictions for both the 1-hour and 8-hour averaged CO levels at all receptors are based on the selected hourly emission level of 70 ppm.

TABLE 2-5: MAXIMUM 1-HOUR CO CONCENTRATIONS FROM VENTILATION BUILDINGS AT AMBIENT RECEPTORS FOR COMPLIANCE DEMONSTRATION

VB	Year					Highest Concentration
	2000	2001	2002	2003	2004	
VB 1	8.9	9.6	9.8	9.4	8.6	9.8
VB 3	11.6	14.5	9.9	13.6	13.9	14.5
VB 4	8.0	7.8	7.7	8.3	7.4	8.3
VB 5	6.5	6.7	6.4	6.5	6.6	6.7
VB 6	5.1	5.1	5.1	5.1	5.1	5.1
VB 7	7.6	7.6	7.6	7.8	7.6	7.8

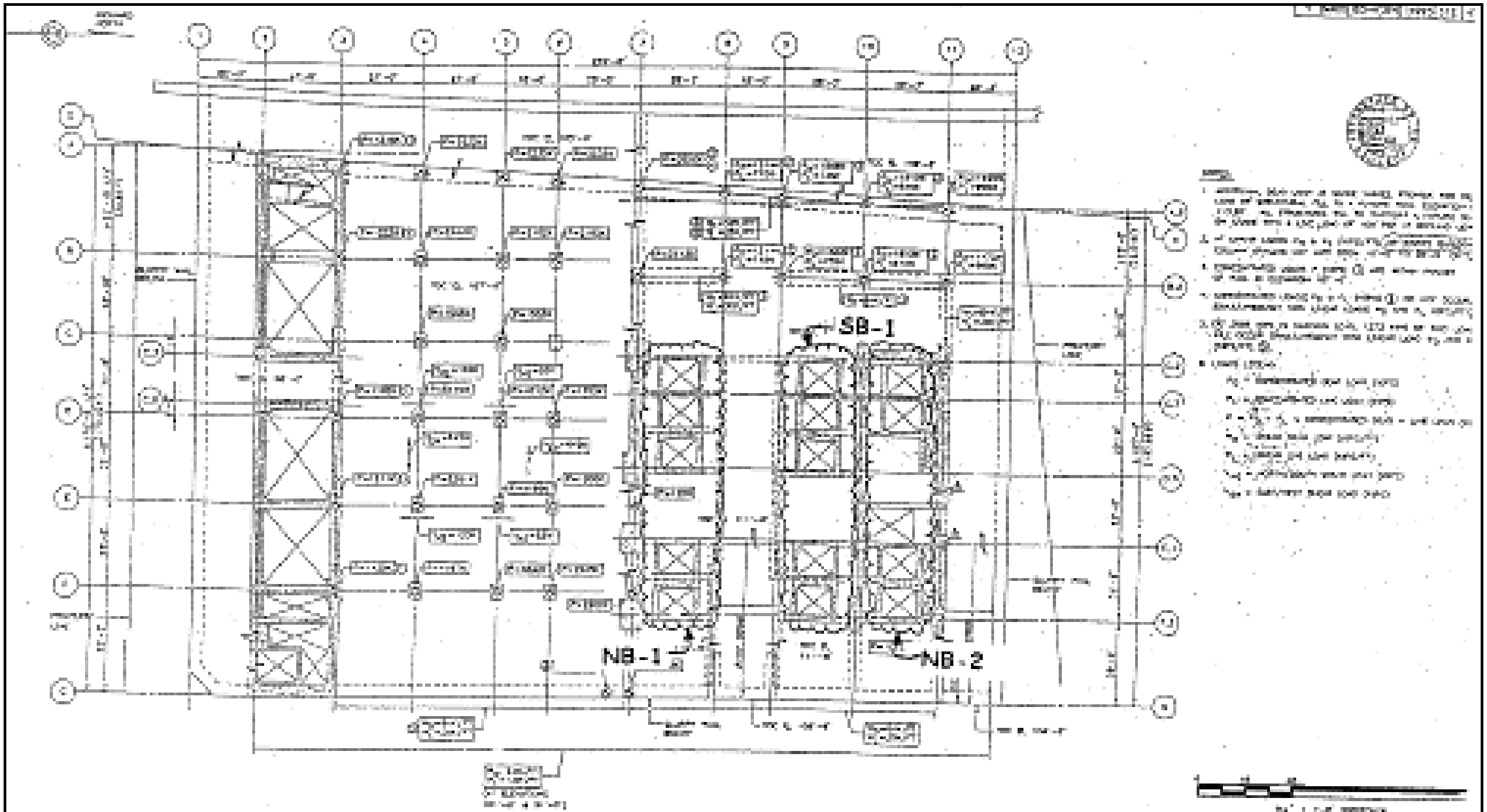
Note: One hour CO NAAQS is 35 ppm; source strength is 70 ppm.

FIGURE 2-2: STACK CONFIGURATION VENTILATION BUILDING 1



VB #1 Roof Plan

FIGURE 2-3: STACK CONFIGURATION VENTILATION BUILDING 3



VB #3 Roof Plan

FIGURE 2-4: STACK CONFIGURATION VENTILATION BUILDING 4

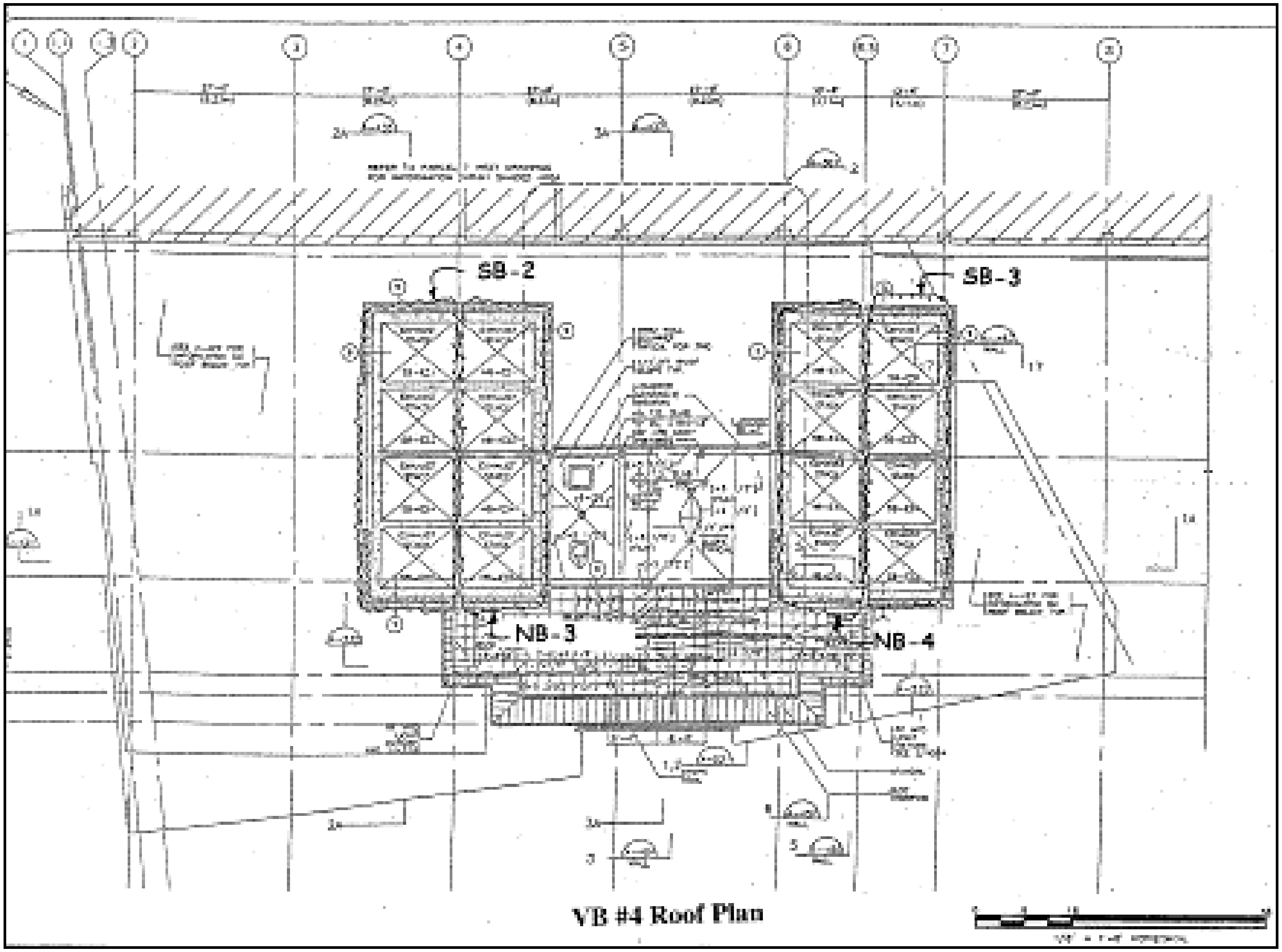
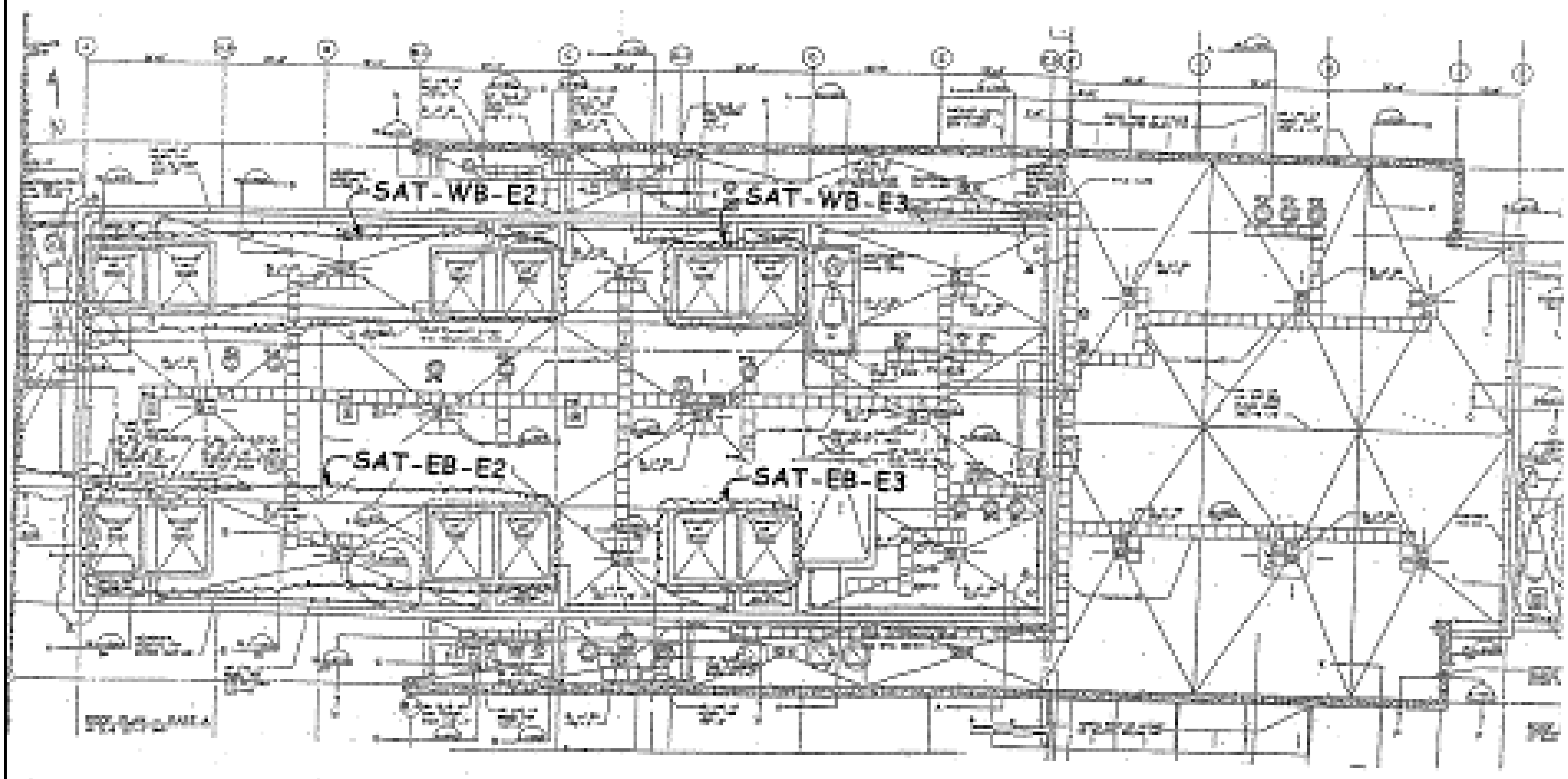
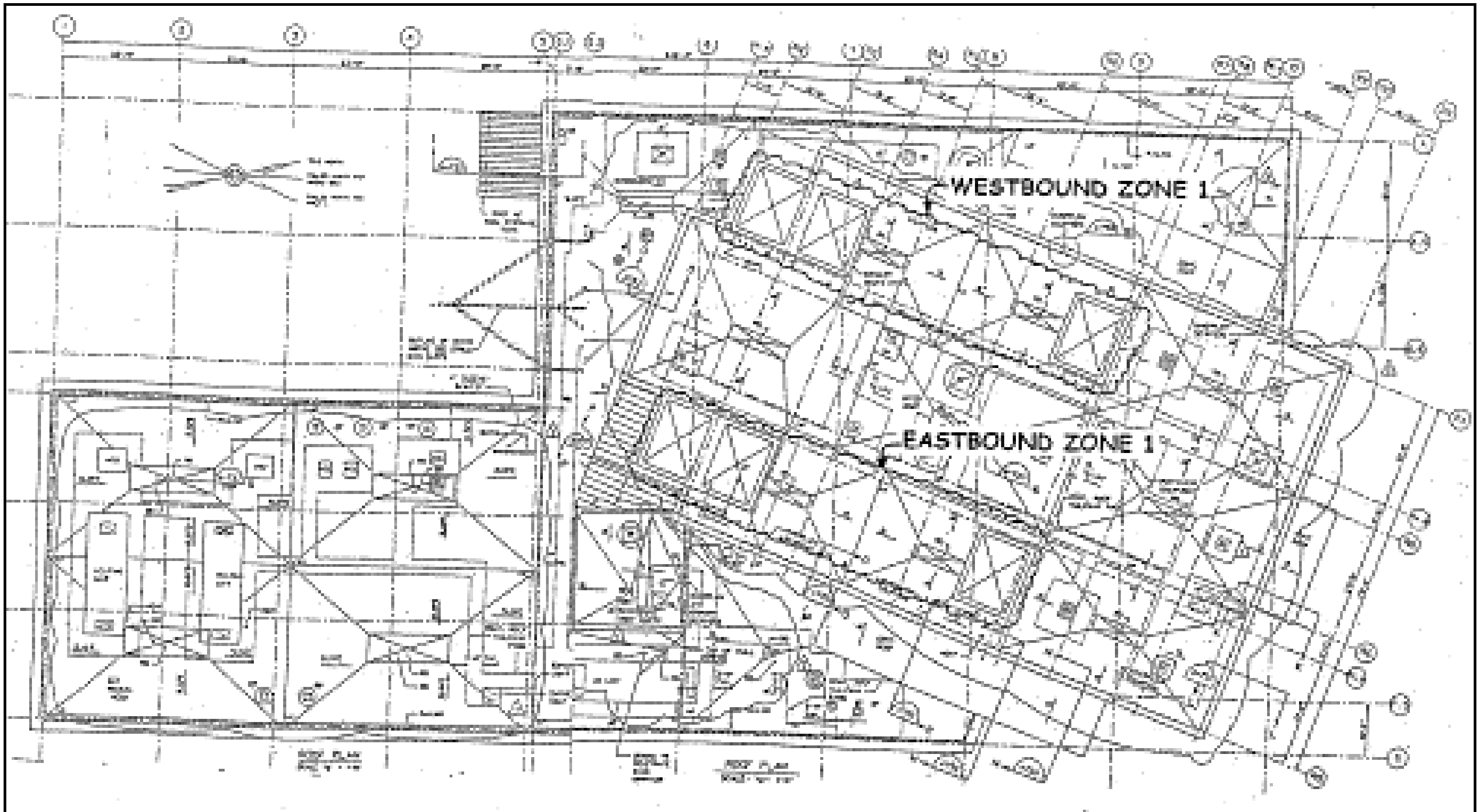


FIGURE 2-5: STACK CONFIGURATION VENTILATION BUILDING 5



VB #5 Roof Plan

FIGURE 2-6: STACK CONFIGURATION VENTILATION BUILDING 6



VB #6 Roof Plan

FIGURE 2-7: STACK CONFIGURATION VENTILATION BUILDING 7

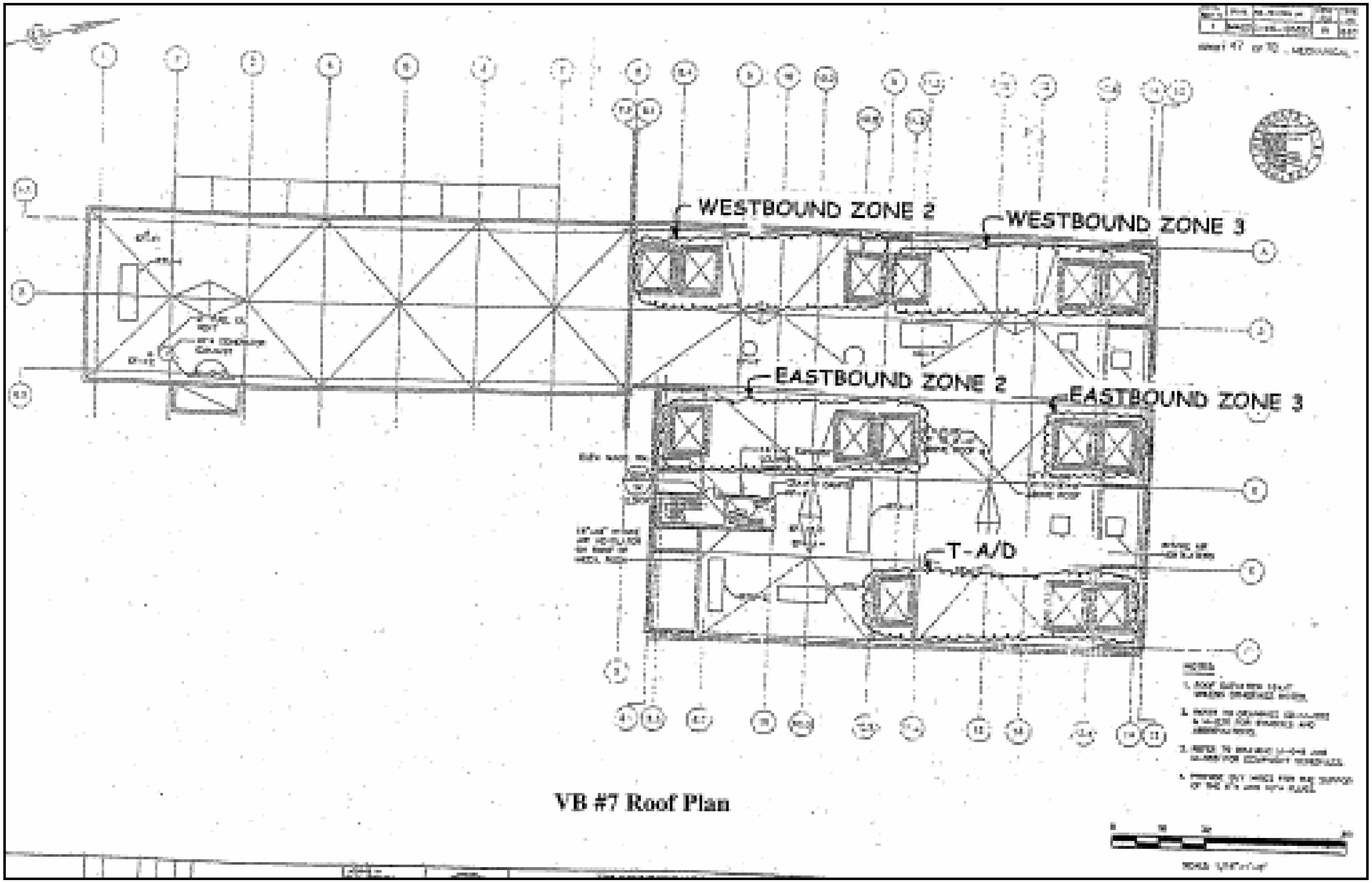


TABLE 2-7: MODEL INPUT PARAMETERS FOR VENTILATION BUILDINGS

Vent Building 3 (I-93 Tunnel)		Temperature		70 °F				Assumed								ISC Input		1 ppm of NOx =		1259.72	ug/m3
Vent Bldg	**Zone**	**# of Fans**	**Capacity/ Fan (CFM)**	**Exhaust Capacity (CFM)**	**Step Used**	**% Capacity Used**	**Flow Rate (CFM)**	**PPM CO**	**Molecular Weigt CO**	**CO Density (lb/ft^3)**	**CFM CO**	**Total Mass Flow CO (g/sec)**	**Mass Flow CO/Stack (g/sec)**	**Area of a single cell (ft^2)**	**Total Exit Area (ft^2)**	**Exit Vel. (m/s)**	**Equ. Dia. (m)**	**NOx Conc. (ppm)***	**NOx Molecular Wt****	**NOx Conc. (ug/m3)**	**NOx Emis. (g/s)**
3	SB-1	5	214000	1070000	4	0.42	449400	70	28	0.07238	31.46	17.21	3.44	106.6	533	4.28	7.94	8.876	30.8	11181.3	2.37
3	NB-1	5	251630	1258150	4	0.42	528423	70	28	0.07238	36.99	20.24	4.05	106.6	533	5.04	7.94	8.876	30.8	11181.3	2.79
3	NB-2	4	284750	1139000	4	0.42	478380	70	28	0.07238	33.49	18.32	4.58	106.6	426.4	5.70	7.10	8.876	30.8	11181.3	2.52

Vent Building 4																					
Vent Bldg	**Zone**	**# of Fans**	**Capacity/ Fan (CFM)**	**Exhaust Capacity (CFM)**	**Step Used**	**% Capacity Used**	**Flow Rate (CFM)**	**PPM CO**	**Molecular Weigt CO**	**CO Density (lb/ft^3)**	**CFM CO**	**Total Mass Flow CO (g/sec)**	**Mass Flow CO/Stack (g/sec)**	**Area of a single cell (ft^2)**	**Total Exit Area (ft^2)**	**Exit Vel. (m/s)**	**Equ. Dia. (m)**	**NOx Conc. (ppm)***	**NOx Molecular Wt****	**NOx Conc. (ug/m3)**	**NOx Emis. (g/s)**
4	SB-2	4	237250	949000	4	0.42	398580	70	28	0.07238	27.90	15.27	3.82	106.6	426.4	4.75	7.10	8.876	30.8	11181.3	2.10
4	SB-3	4	282625	1130500	4	0.42	474810	70	28	0.07238	33.24	18.19	4.55	106.6	426.4	5.66	7.10	8.876	30.8	11181.3	2.50
4	NB-3	4	221250	885000	4	0.42	371700	70	28	0.07238	26.02	14.24	3.56	106.6	426.4	4.43	7.10	8.876	30.8	11181.3	1.96
4	NB-4	4	202250	809000	4	0.42	339780	70	28	0.07238	23.78	13.01	3.25	106.6	426.4	4.05	7.10	8.876	30.8	11181.3	1.79

Vent Building 1 (I-90 Tunnel)																					
Vent Bldg	**Zone**	**# of Fans**	**Capacity/ Fan (CFM)**	**Exhaust Capacity (CFM)**	**Step Used**	**% Capacity Used**	**Flow Rate (CFM)**	**PPM CO**	**Molecular Weigt CO**	**CO Density (lb/ft^3)**	**CFM CO**	**Total Mass Flow CO (g/sec)**	**Mass Flow CO/Stack (g/sec)**	**Area of a single cell (ft^2)**	**Total Exit Area (ft^2)**	**Exit Vel. (m/s)**	**Equ. Dia. (m)**	**NOx Conc. (ppm)***	**NOx Molecular Wt****	**NOx Conc. (ug/m3)**	**NOx Emis. (g/s)**
1	SAT-Ramp D-E1	2	171500	343000	4	0.42	144060	70	28	0.07238	10.08	5.52	2.76	106.6	213.2	3.43	5.02	8.876	30.8	11181.3	0.76
1	SAT-WB-E1	3	230400	691200	4	0.42	290304	70	28	0.07238	20.32	11.12	3.71	106.6	319.8	4.61	6.15	8.876	30.8	11181.3	1.53
1	SAT-EB-E1	2	281820	563640	4	0.42	236729	70	28	0.07238	16.57	9.07	4.53	106.6	213.2	5.64	5.02	8.876	30.8	11181.3	1.25
1	SAT-Ramp L/HOV-E1	4	235250	941000	4	0.42	395220	70	28	0.07238	27.67	15.14	3.78	106.6	426.4	4.71	7.10	8.876	30.8	11181.3	2.08

Vent Building 5																					
Vent Bldg	**Zone**	**# of Fans**	**Capacity/ Fan (CFM)**	**Exhaust Capacity (CFM)**	**Step Used**	**% Capacity Used**	**Flow Rate (CFM)**	**PPM CO**	**Molecular Weigt CO**	**CO Density (lb/ft^3)**	**CFM CO**	**Total Mass Flow CO (g/sec)**	**Mass Flow CO/Stack (g/sec)**	**Area of a single cell (ft^2)**	**Total Exit Area (ft^2)**	**Exit Vel. (m/s)**	**Equ. Dia. (m)**	**NOx Conc. (ppm)***	**NOx Molecular Wt****	**NOx Conc. (ug/m3)**	**NOx Emis. (g/s)**
5	SAT-WB-E2	4	260000	1040000	4	0.42	436800	70	28	0.07238	30.58	16.73	4.18	106.6	426.4	5.20	7.10	8.876	30.8	11181.3	2.30
5	SAT-WB-E3	2	196500	393000	4	0.42	165060	70	28	0.07238	11.55	6.32	3.16	106.6	213.2	3.93	5.02	8.876	30.8	11181.3	0.87
5	SAT-EB-E2	4	278000	1112000	4	0.42	467040	70	28	0.07238	32.69	17.89	4.47	106.6	426.4	5.56	7.10	8.876	30.8	11181.3	2.46
5	SAT-EB-E3	2	279000	558000	4	0.42	234360	70	28	0.07238	16.41	8.98	4.49	106.6	213.2	5.58	5.02	8.876	30.8	11181.3	1.24

Vent Building 6 (Ted Wiliam Tunnel)																					
Vent Bldg	**Zone**	**# of Fans**	**Capacity/ Fan (CFM)**	**Exhaust Capacity (CFM)**	**Step Used**	**% Capacity Used**	**Flow Rate (CFM)**	**PPM CO**	**Molecular Weigt CO**	**CO Density (lb/ft^3)**	**CFM CO**	**Total Mass Flow CO (g/sec)**	**Mass Flow CO/Stack (g/sec)**	**Area of a single cell (ft^2)**	**Total Exit Area (ft^2)**	**Exit Vel. (m/s)**	**Equ. Dia. (m)**	**NOx Conc. (ppm)***	**NOx Molecular Wt****	**NOx Conc. (ug/m3)**	**NOx Emis. (g/s)**
6	Eastbound Zone 1	3	300000	900000	4	0.42	378000	70	28	0.07238	26.46	14.48	4.83	106.6	319.8	6.00	6.15	8.876	30.8	11181.3	1.99
6	Westbound Zone 1	3	300000	900000	4	0.42	378000	70	28	0.07238	26.46	14.48	4.83	106.6	319.8	6.00	6.15	8.876	30.8	11181.3	1.99

Vent Building 7																					
Vent Bldg	**Zone**	**# of Fans**	**Capacity/ Fan (CFM)**	**Exhaust Capacity (CFM)**	**Step Used**	**% Capacity Used**	**Flow Rate (CFM)**	**PPM CO**	**Molecular Weigt CO**	**CO Density (lb/ft^3)**	**CFM CO**	**Total Mass Flow CO (g/sec)**	**Mass Flow CO/Stack (g/sec)**	**Area of a single cell (ft^2)**	**Total Exit Area (ft^2)**	**Exit Vel. (m/s)**	**Equ. Dia. (m)**	**NOx Conc. (ppm)***	**NOx Molecular Wt****	**NOx Conc. (ug/m3)**	**NOx Emis. (g/s)**
7	Eastbound Zone 2	3	274000	822000	4	0.42	345240	70	28	0.07238	24.17	13.22	4.41	106.6	319.8	5.48	6.15	8.876	30.8	11181.3	1.82
7	Westbound Zone 2	3	231000	693000	4	0.42	291060	70	28	0.07238	20.37	11.15	3.72	106.6	319.8	4.62	6.15	8.876	30.8	11181.3	1.54
7	Eastbound Zone 3	2	226000	452000	4	0.42	189840	70	28	0.07238	13.29	7.27	3.64	106.6	213.2	4.52	5.02	8.876	30.8	11181.3	1.00
7	Westbound Zone 3	3	203000	609000	4	0.42	255780	70	28	0.07238	17.90	9.80	3.27	106.6	319.8	4.06	6.15	8.876	30.8	11181.3	1.35
7	T-A/D	3	194333	583000	4	0.42	244860	70	28	0.07238	17.14	9.38	3.13	106.6	319.8	3.89	6.15	8.876	30.8	11181.3	1.29

Notes:

1. Assumes all fans in a given zone are operating simultaneously.
2. Higher bound assumed conditions represent 70 ppm CO and Step 4 (a high ventilation rate for modeling purpose).

* NOx (ppm) = 0.196 + 0.124CO (ppm)

** NO_x molecular weight assumed for 95% NO and 5% NO_2

TABLE 2-6: MAXIMUM 8-HOUR CO CONCENTRATIONS FROM VENTILATION BUILDINGS AT AMBIENT RECEPTORS FOR COMPLIANCE DEMONSTRATION

VB	Year					Highest Concentration
	2000	2001	2002	2003	2004	
VB 1	4.3	4.8	4.0	4.4	4.1	4.8
VB 3	4.0	5.1	3.6	4.8	4.0	5.1
VB 4	4..0	3.9	3.7	4.1	3.9	4.1
VB 5	3.9	3.9	4.0	4.0	3.9	4.0
VB 6	3.3	3.3	3.3	3.3	3.4	3.4
VB 7	4.7	4.5	4.5	4.8	4.5	4.8

Note: Eight hour CO NAAQS is 9 ppm; source strength is 70 ppm.

Based on these modeling results, no further CO impact analysis iterations were performed.

NO_2 Analysis

The NO_2 in-tunnel concentration was estimated using the Project-specific regression model as follows:

$$NO_x = 0.196 + 0.124\ CO$$

For CO at 70 ppm, the equivalent in-tunnel NO_x concentration would be 8.88 ppm.

By following the similar modeling process used in the CO analysis, the NO_x concentration levels contributed by the VBs at all receptors were calculated using the ISC model. For air quality compliance demonstration purpose, these NO_x concentration levels will need to be converted into NO_2 because the applicable ambient air quality standard and the Mass DEP Policy Guideline Value are set for NO_2, not NO_x.

Since most of the NO_x emitted by vehicles is mostly in the form of NO and the reaction of NO with O_3 is the predominant pathway for conversion of NO to NO_2, the final calculation of NO_2 was carried out by applying the Ozone Limiting Method (OLM). The resultant hourly NO_2 concentrations derived from the OLM were summarized in Table 2-8. As shown in the table, the maximum hourly NO_2 concentration of 0.16ppm (296.6 µg/m^3), which is the highest among all VBs was predicted for VB7. This maximum concentration is below the Mass DEP Policy Guideline value 0.17ppm (320 µg/m^3) for NO_2.

TABLE 2-8: MAXIMUM 1-HOUR NO_2 CONCENTRATIONS FROM VENTILATION BUILDINGS AT AMBIENT RECEPTORS FOR COMPLIANCE DEMONSTRATION

VB	Parameter	Year					Highest Concentration
		2000	2001	2002	2003	2004	
VB 1	NO_2 (Bckgr)	0.017	0.022	0.036	0.025	0.021	
	NO_2 (Receptor)	0.115	0.122	0.094	0.127	0.114	0.127
VB 3	NO_2 (Bckgr)	0.076	0.037	0.025	0.036	0.032	
	NO_2 (Receptor)	0.106	0.125	0.122	0.099	0.095	0.125
VB 4	NO_2 (Bckgr)	0.052	0.029	0.014	0.025	0.021	
	NO_2 (Receptor)	0.102	0.110	0.120	0.127	0.109	0.127
VB 5	NO_2 (Bckgr)	0.031	0.039	0.027	0.028	0.017	
	NO_2 (Receptor)	0.106	0.129	0.131	0.119	0.109	0.131
VB 6	NO_2 (Bckgr)	---	0.032	0.037	0.023	0.016	
	NO_2 (Receptor)	0.093	0.127	0.141	0.132	0.110	0.141
VB 7	NO_2 (Bckgr)	0.017	0.039	0.037	0.024	0.015	
	NO_2 (Receptor)	0.117	0.130	0.158	0.133	0.128	0.158

Notes: Mass DEP NO_2 one hour Guideline is 0.17 ppm.
All receptor concentrations include background levels.

For compliance demonstration with the NO_2 annual NAAQS, a realistic annual average NO_x emission rate was used instead of the maximum hourly NO_x emission rate to determine the air quality impacts. The reduction factor for adjusting the maximum hourly emission rate to an annual average value was derived from five months of CO measurements made inside the DST along the I-93 Mainline and the I-90 Collector during 2005 in conjunction with the use of the Project-specific regression formulation that calculates NO_x based on the CO measurements. Analysis of the CO monitoring data indicated that the ratio of the 5-month average hourly value to the highest recorded hourly CO value is 0.23. The corresponding reduction factor for NO_x was calculated to be 0.25. Finally, a conservative conversion factor of 75% on an annual basis was further applied to the annual NO_x results for converting NO_x to NO_2 as suggested by the EPA (EPA, 91-180.6).

Results of the maximum annual NO_2 impacts for all VBs are summarized in Table 2-9. The maximum predicted annual NO_2 concentration, including the appropriate background, is 0.03 ppm (61 µg/m^3), which is well below the annual NO_2 NAAQS of 0.05 ppm.

TABLE 2-9: MAXIMUM ANNUAL NO_2 CONCENTRATIONS FROM VENTILATION BUILDINGS AT AMBIENT RECEPTORS FOR COMPLIANCE DEMONSTRATION

VB	Year					Highest Concentration
	2000	2001	2002	2003	2004	
VB 1	0.026	0.026	0.026	0.026	0.025	0.026
VB 3	0.024	0.025	0.024	0.025	0.025	0.025
VB 4	0.024	0.024	0.024	0.024	0.025	0.025
VB 5	0.028	0.028	0.028	0.028	0.028	0.028
VB 6	0.025	0.025	0.025	0.025	0.024	0.025
VB 7	0.031	0.030	0.030	0.029	0.030	0.031

Notes: Annual NO_2 NAAQS is 0.05 ppm. Background NO_2 is 0.023 ppm.

Based on these modeling results, no further NO_2 impact analysis iterations were performed.

PM_{10} Analysis

Similarly, the PM_{10} emission limits for the VBs were identified by starting the modeling process at an assumed concentration (500 µg/m^3). The 500 µg/m^3 is the worst case that was selected based on the levels measured in tunnels. Note that this assumed hourly PM_{10} emission level was used for both the 24-hour and annual average predictions.

The 24-hour and annual modeling results for all VBs are presented in Tables 2-10 and 2-11, respectively. When added to the appropriate background PM_{10} levels, the maximum 24-hour impact was 73 µg/m^3 and the maximum annual impact was 26.1 µg/m^3. Both these maximums are caused by emissions from VB 7 and they are well below the annual and 24-hour NAAQS values of 50 µg/m^3 and 150 µg/m^3, respectively.

TABLE 2-10: MAXIMUM 24-HOUR PM_{10} CONCENTRATIONS FROM VENTILATION BUILDINGS AT AMBIENT RECEPTORS FOR COMPLIANCE DEMONSTRATION (µg/m^3)

VB	Year					Highest Concentration
	2000	2001	2002	2003	2004	
VB 1	68.5	69.8	68.2	68.9	68.7	69.8
VB 3	65.4	68.3	63.9	66.9	65.3	68.3
VB 4	66.3	66.6	65.6	67.9	66.0	67.9
VB 5	69.0	70.3	69.7	68.0	68.0	70.3
VB 6	66.1	66.0	65.5	65.7	66.2	66.2
VB 7	72.4	73.0	72.5	72.6	72.0	73.0

Notes: 24-hour PM_{10} NAAQS is 150 µg/m^3 Background PM_{10} level is 60.6 µg/m^3

TABLE 2-11: MAXIMUM ANNUAL PM_{10} CONCENTRATIONS FROM VENTILATION BUILDINGS FOR COMPLIANCE DEMONSTRATION (µg/m^3)

VB	Year					Highest Concentration
	2000	2001	2002	2003	2004	
VB 1	24.0	24.1	24.0	24.0	23.8	24.1
VB 3	23.3	23.4	23.3	23.4	23.4	23.4
VB 4	23.2	23.3	23.1	23.3	23.3	23.3
VB 5	24.9	24.8	24.8	24.8	24.8	24.9
VB 6	23.5	23.5	23.6	23.5	23.4	23.6
VB 7	26.1	25.9	25.9	25.6	25.9	26.1

Note2: Annual PM_{10} NAAQS is 50 µg/m^3 Background PM_{10} level is 22.6 µg/m^3

Based on these modeling results, no further PM_{10} impact analysis iterations were performed.

2.5.2 For Longitudinal Ventilation – Exit Ramps and DST

2.5.2.1 Modeling Procedures to Determine the Impact of Exit Portal Emissions

The plume of exhaust air that comes out of an exit portal in the wake of exiting vehicles has high pollutant concentrations because of the limited dispersion of pollutants within the tunnel. This plume maintains its integrity for a distance downstream of the exit portal due to the momentum created by the moving cars. This distance depends on the geometry of the roadway after the tunnel exit, the traffic flow characteristics, such as speed and density, meteorological conditions (wind direction), and other factors affecting the turbulence and dispersion of the plume. Given the complexity of the air flow patterns and geometries of tunnel portals, physical models were used to analyze the effect of the tunnel emissions.

1996 CA/T Physical Simulation Studies

Physical simulation studies (i.e., wind tunnel tests) were performed in support of the air quality evaluation for the *Notice of Project Change (NPC)/Environmental Reevaluation (ER) for the Implementation of Longitudinal Ventilation in the Area North of Causeway Street and Central Area, October 1996* (1996 Longitudinal Ventilation NPC/ER).

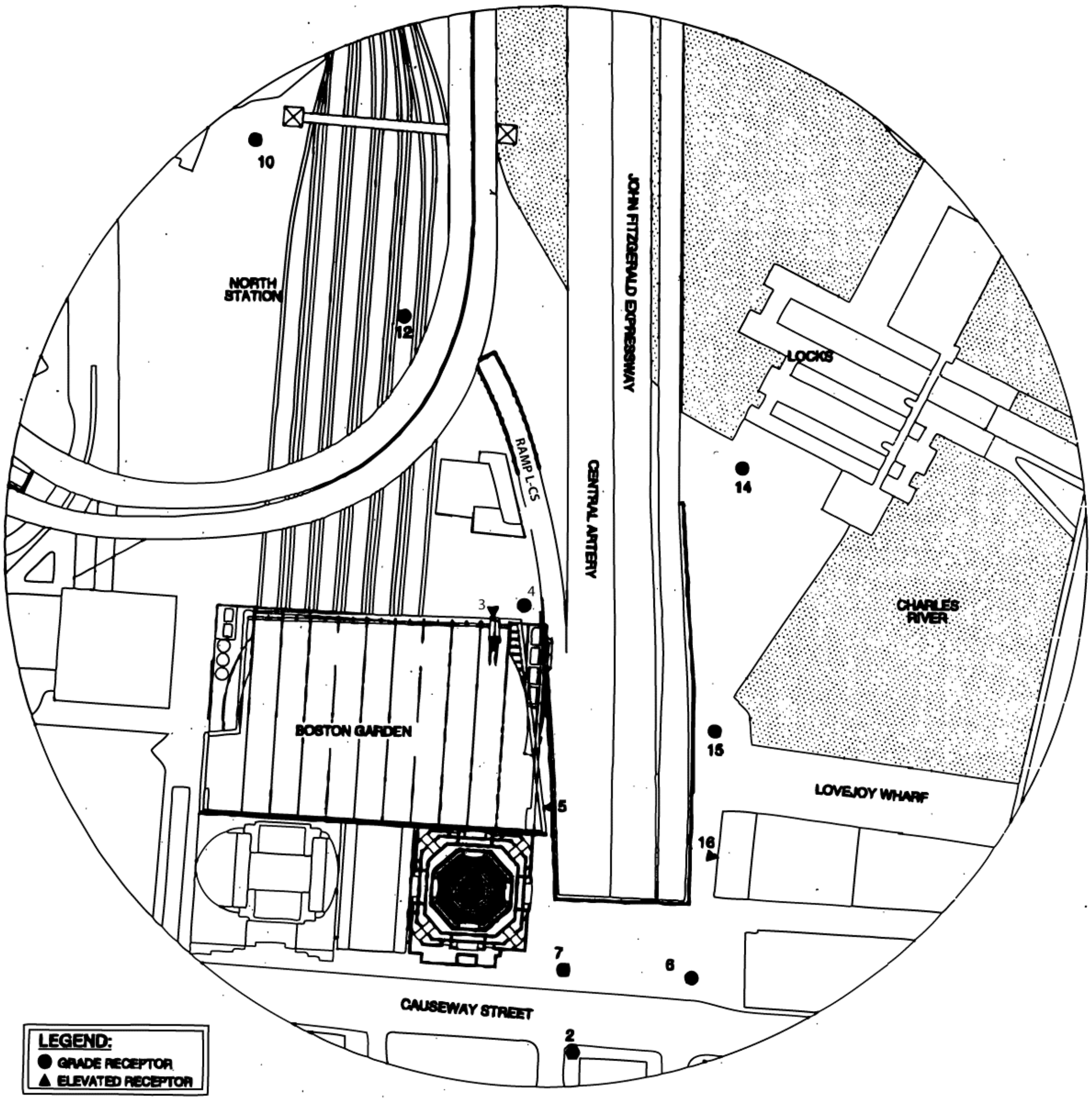
The changes analyzed in the 1996 Longitudinal Ventilation NPC/ER were the direct results of the emissions that previously were vented through the exhaust stacks of VB 8 (eliminated with longitudinal ventilation), and that now are exhausted through the exit portals of ramps CN-S and L-CS. Another change included a small portion of emissions that previously were vented through VBs 3 and 4, and is currently vented through the exit portals of the ramps SA-CN, ST-CN, ST-SA, CS-SA and CS-P.

Another physical simulation study was performed for Ramp F as part of the air quality evaluation for the Notice of Project Change (NPC)/Environmental Reevaluation (ER) for the South Bay/South Boston Areas. In order to simplify the ducting system for VB 5, the ventilation of exit ramp F was removed from VB 5 and exit ramp F is longitudinally ventilated by the piston action of the vehicles with the addition of jet fans exhausting the air through its exit portal during emergency conditions.

Figures 2-8 to 2-13 identify the location of each ramp analyzed.

In order to replicate the effects of the air flows created by the moving traffic at these exit ramps, six 1:100 and 1:200 scale models were built at the RWDI wind tunnel testing facility in Guelph, Ontario.

FIGURE 2-8: RAMP L-CS



Site Plan - Ramp L-CS (Above Ground Intake Structure)	True North	Drawing No. 7	RWDI
		Scale: 1"=225'	
Central Artery Air Quality Assessment - Boston, Mass.	Job No. 96-131	Date: Oct. 21,1996	

FIGURE 2-9: RAMP SA-CN

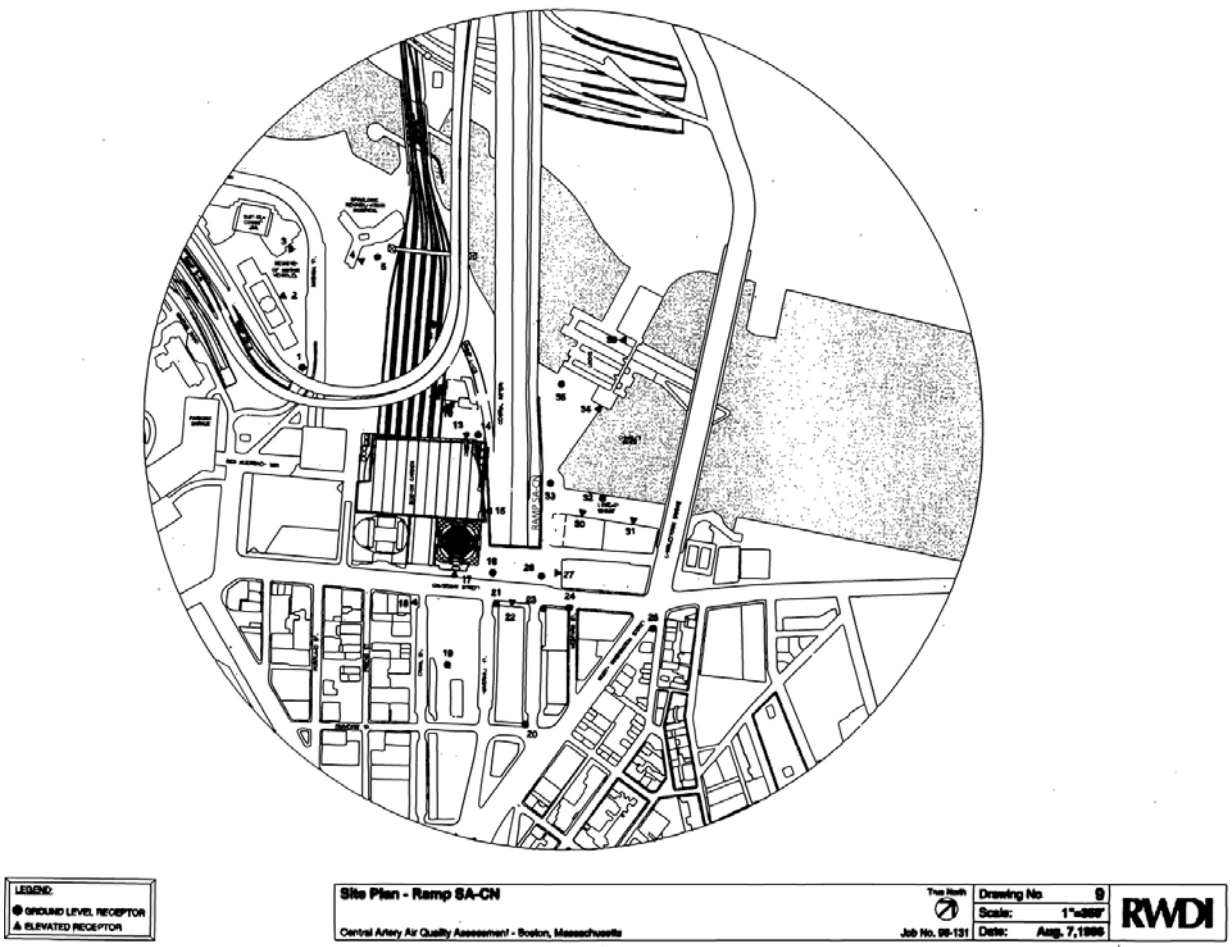
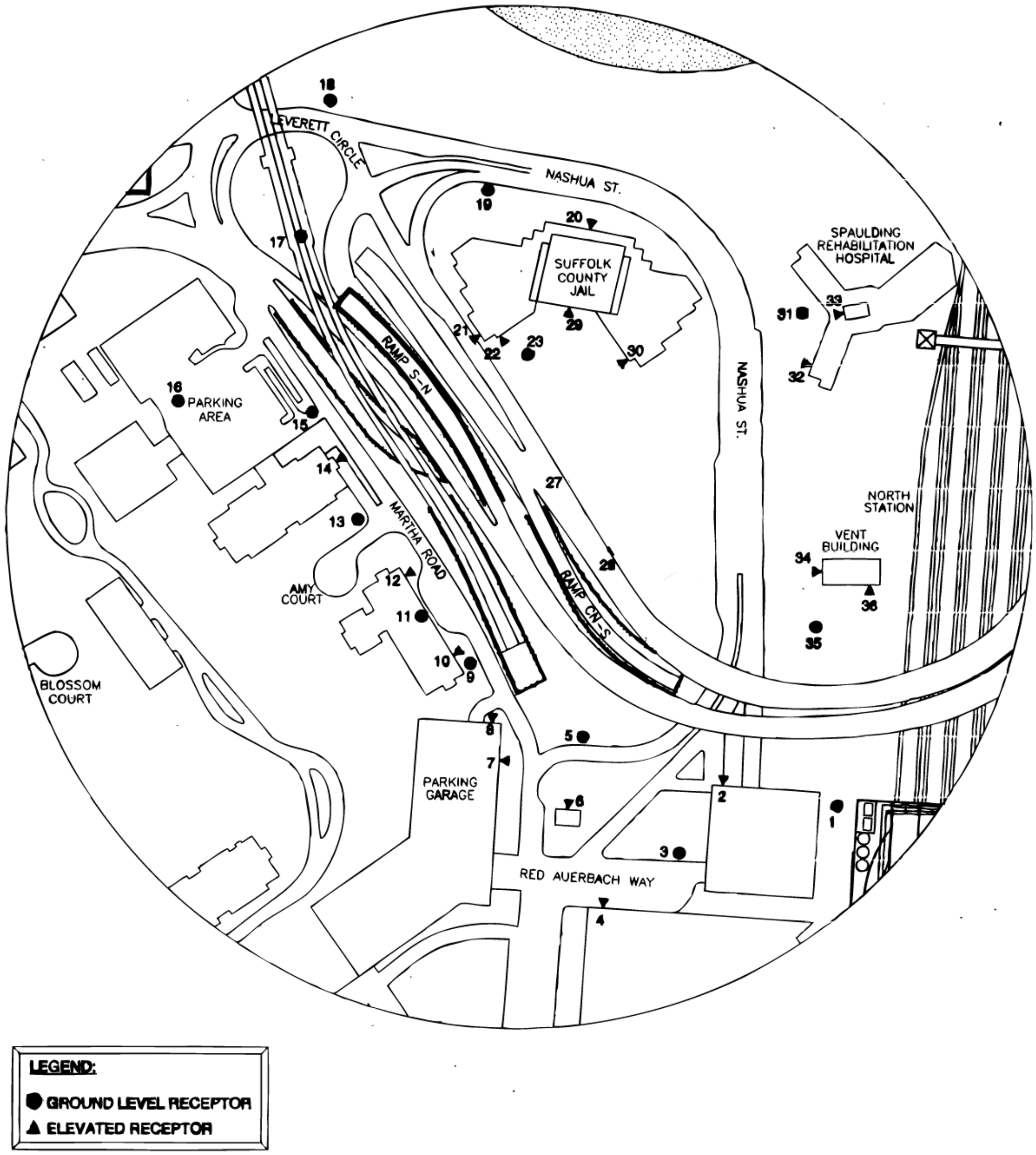


FIGURE 2-10: RAMP CN-S



Site Plan - Ramp CN-S	True North	Drawing No. 10	RWDI
		Scale: 1"=225'	
Central Artery Air Quality Assessment - Boston, Massachusetts	Job No. 96-131	Date: Oct. 21,1996	

FIGURE 2-11: RAMP ST-SA

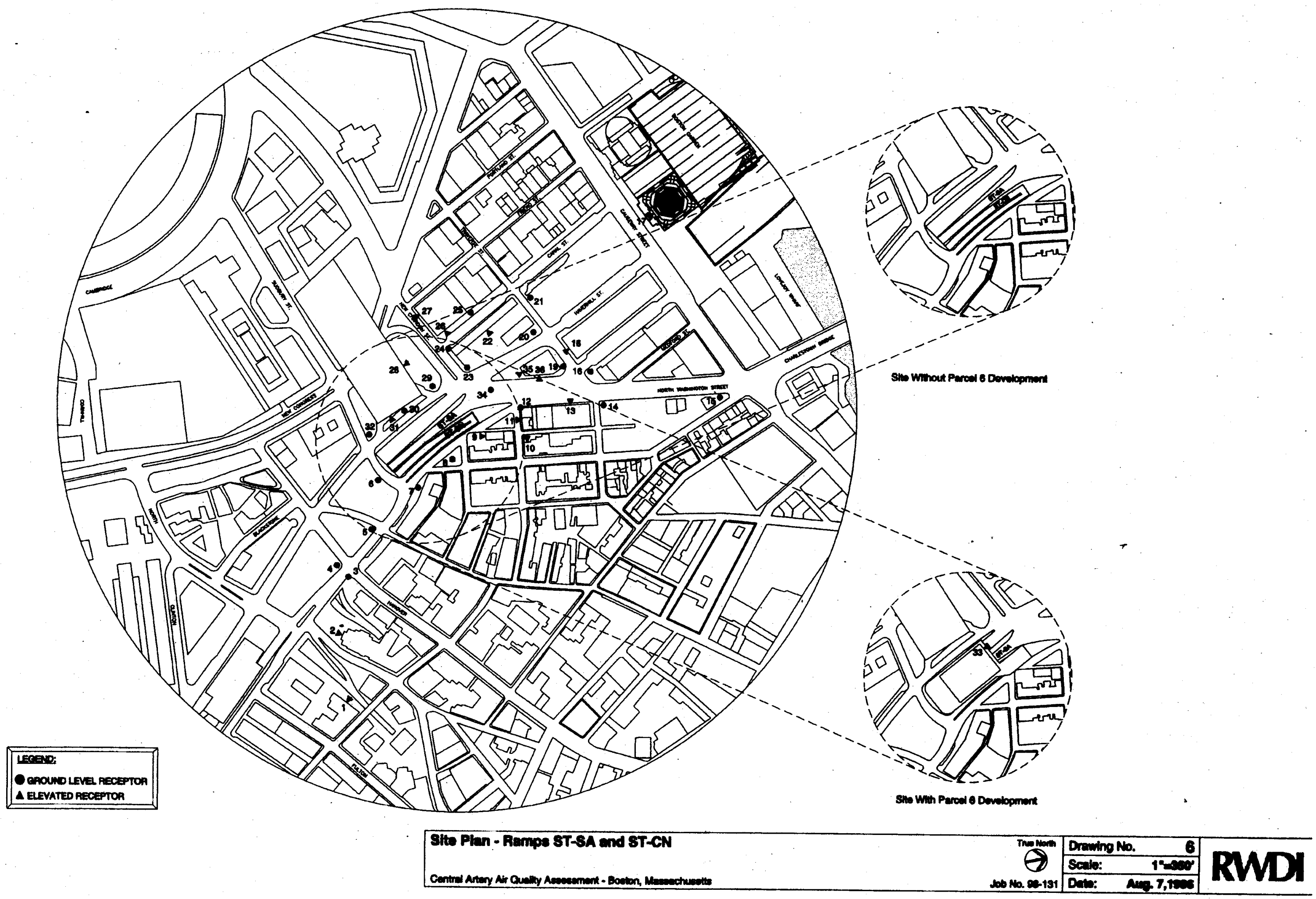


FIGURE 2-12: RAMP CS-SA

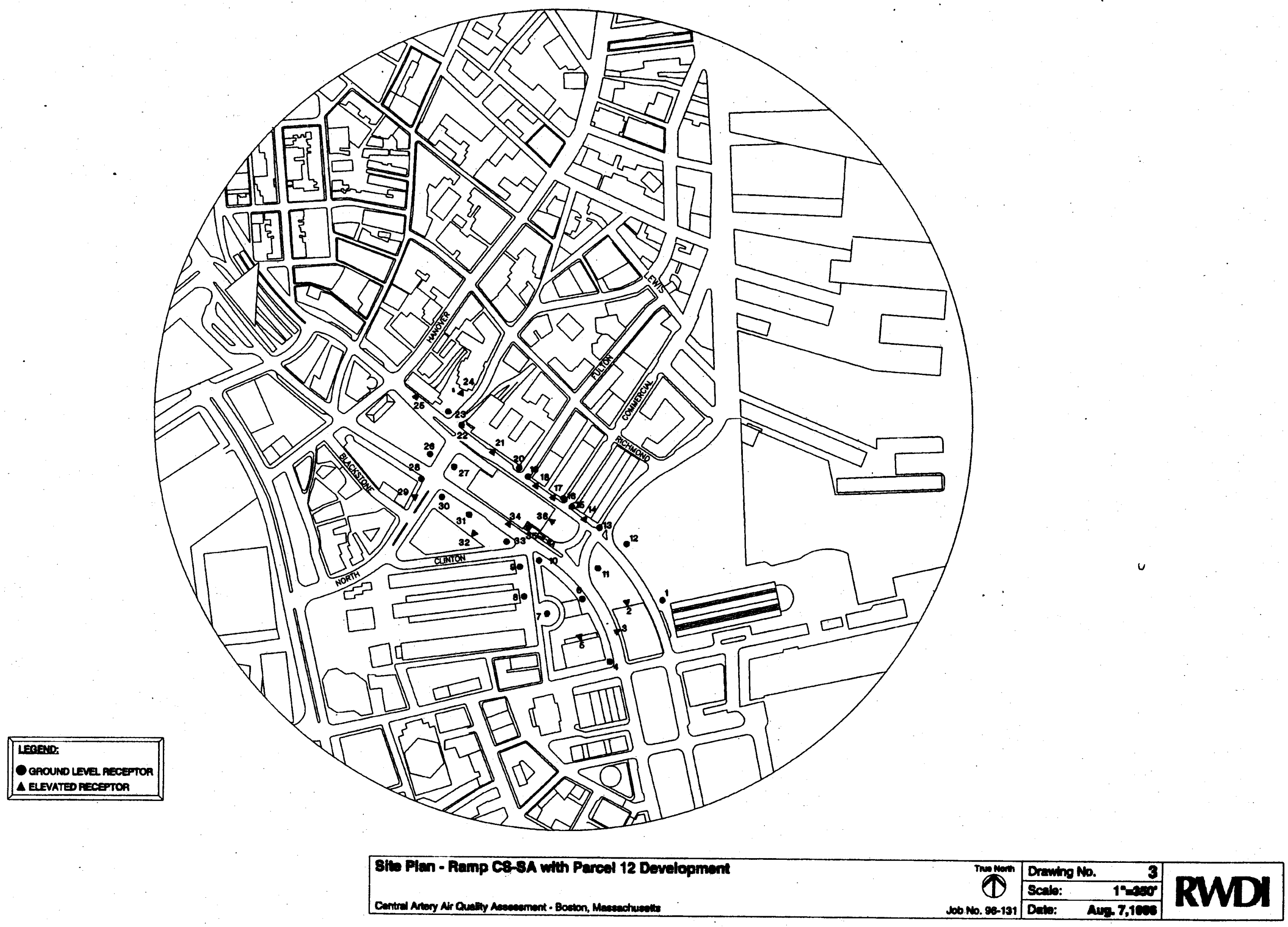


FIGURE 2-13: RAMP CS-P

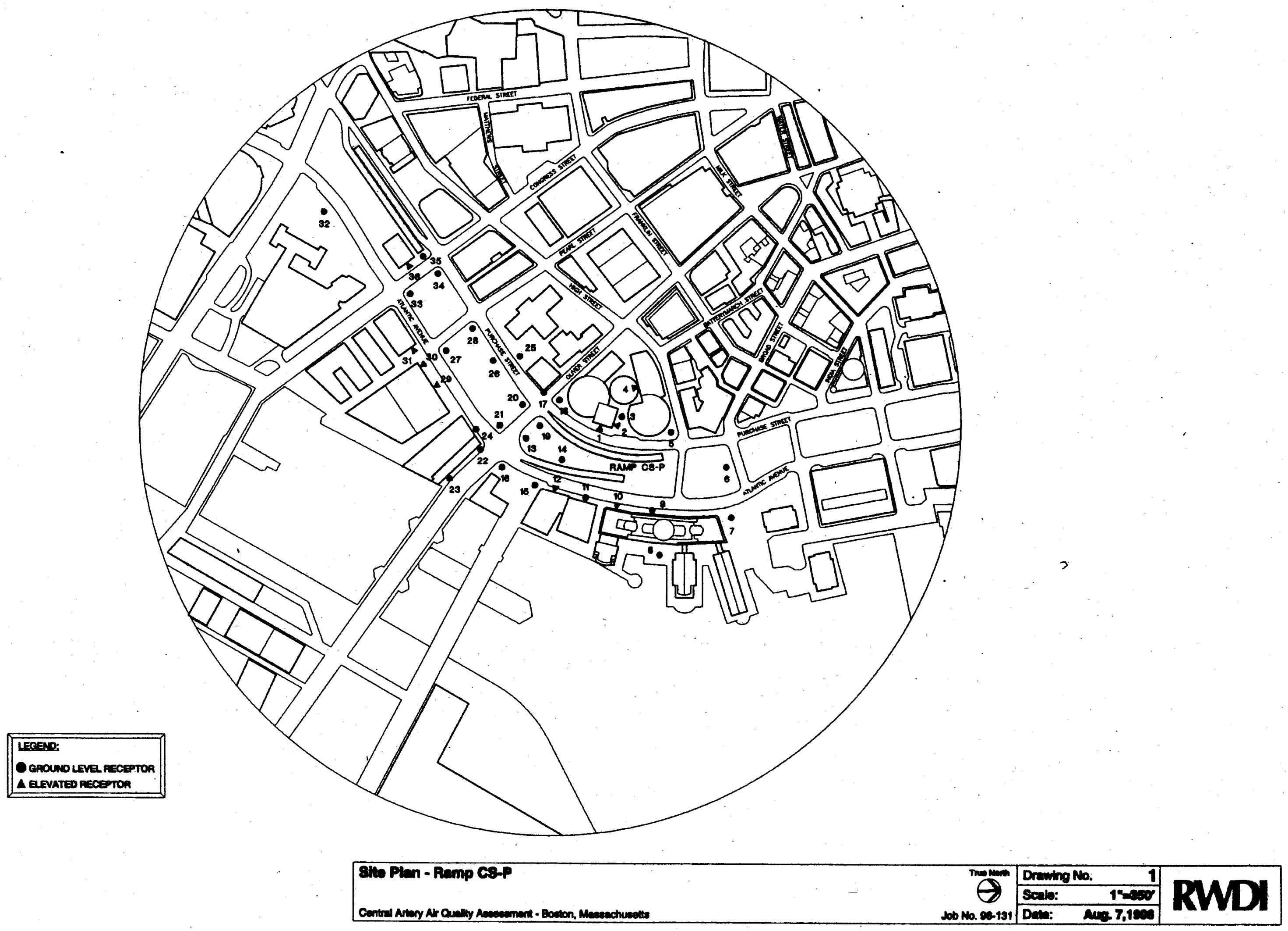
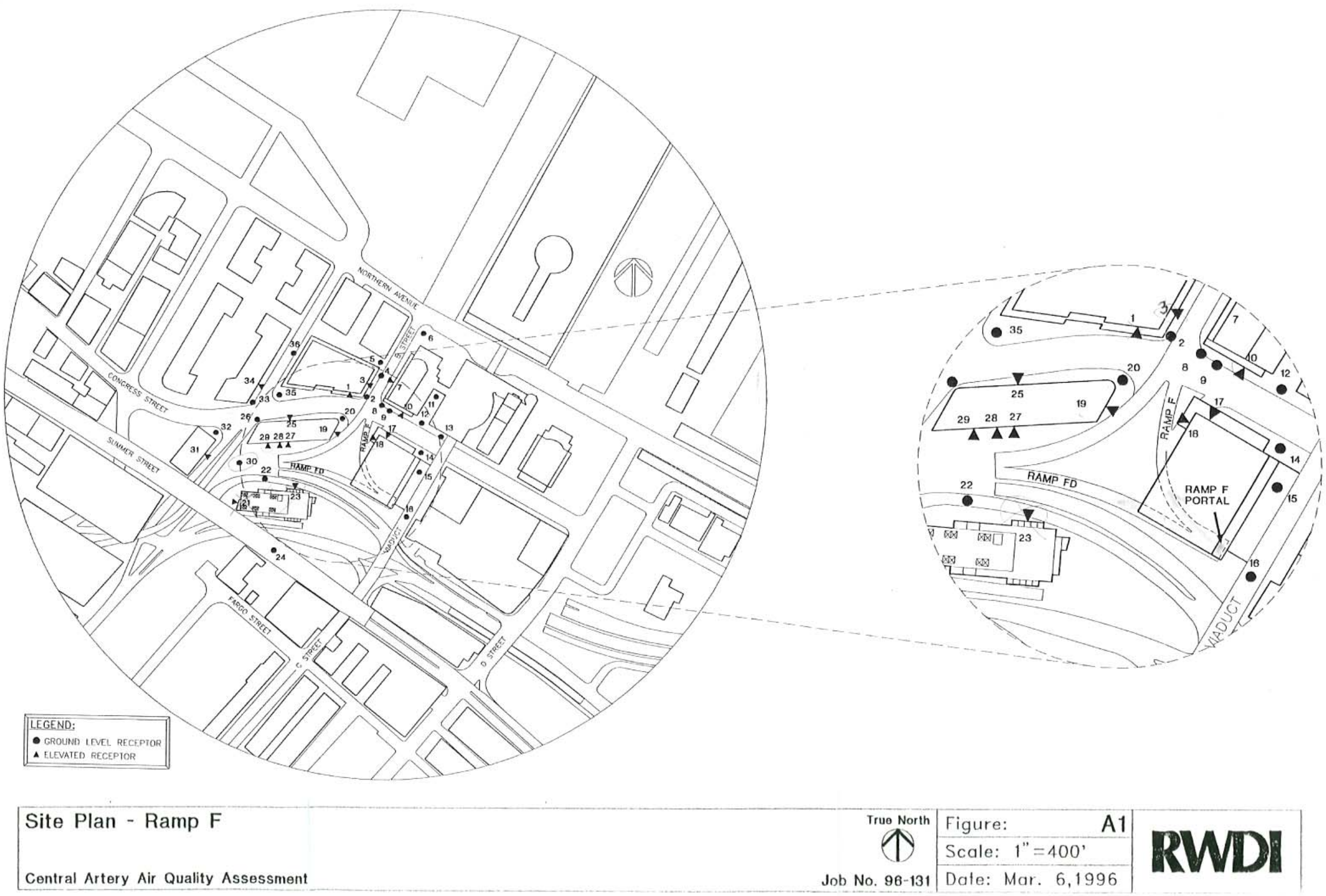


FIGURE 2-14: RAMP F



Each model included the individual ramps, and its surrounding buildings within 800 to 1,600 feet from each portal. The scenarios with and without the development of parcels 6 and 12 were also studied. The effects of the moving vehicles were simulated using moving belts, with attached semi spheres representing the aerodynamic characteristics of the predicted traffic speed and density. The model scale vehicle drag took into account the modeled vehicles and the conveyor belt itself.

Flow visualization tests were initially performed to determine the most likely location of the highest impacts, and detailed tracer gas tests were performed at the identified high impact locations, including sensitive public areas, and air intakes of the surrounding buildings. Tracer gas tests were performed at the wind tunnel facility for each ramp, at each specified traffic and parcel development scenario. The tracer gas concentration measured at each receptor location was recorded as a percentage of the gas concentration measured at the exit portal (this data provides what can be described as a dilution ratio for each location).

A full description of the study methodology and results was prepared in the report *Physical Simulation Study for the Implementation of Longitudinal Ventilation Systems in the Area North of Causeway and Central Area*, by RWDI, October 1996. The report was submitted to Mass DEP as part of the 1996 Longitudinal Ventilation NPC/ER.

The detailed modeling procedures used for determination of the longitudinal ventilation emission impacts and emission limits can be found in Appendix B, “Air Quality Analysis Protocol for Determination of Emission Limits as Part of the Operating Certification of the Project Ventilation Systems” of this document.

2005 DST Physical Simulation Study

Due to the proposed commercial building development immediately downstream and adjacent to the tunnel portal, a physical simulation study was performed to evaluate the effects of tunnel motor vehicle emissions on the existing environment, the proposed building configurations and the associated sidewalks.

The objective of the 2005 exhaust dispersion study was to evaluate different Build scenarios (from No-Build to fully developed Parcels 24, 25 and 26a), and how these scenarios would affect the dispersion of exhaust from the two vehicle tunnel portals located south of Kneeland Street. These two portals carry the I-93 south-bound mainline traffic (CASB), and the I-90 collector traffic (Ramp H/Slip Ramp). The sources included in this assessment were the exhausts from the CASB and Ramp H/Slip Ramp exit portals. Three physical configurations evaluated included:

- Configuration 1 – the relocated CASB portal (400 feet south of Kneeland Street) with development at Parcels 24, 25 and 26a (Figure 2-15)
- Configuration 2 – the existing CASB portal location with development at Parcels 24 and 26a and low existing retaining wall (Figure 2-16)
- Configuration 3A – the existing “No-Build” condition without any development on Parcels 24, 25 and 26a (Figure 2-17)

The exhaust flow from the two portals was simulated using a fan system exhausting through the modeled vehicle tunnels. The pollutants of concern for this assessment were CO, NO_2 and PM_{10}.

FIGURE 2-15: DEWEY SQUARE TUNNEL – CONFIGURATION 1

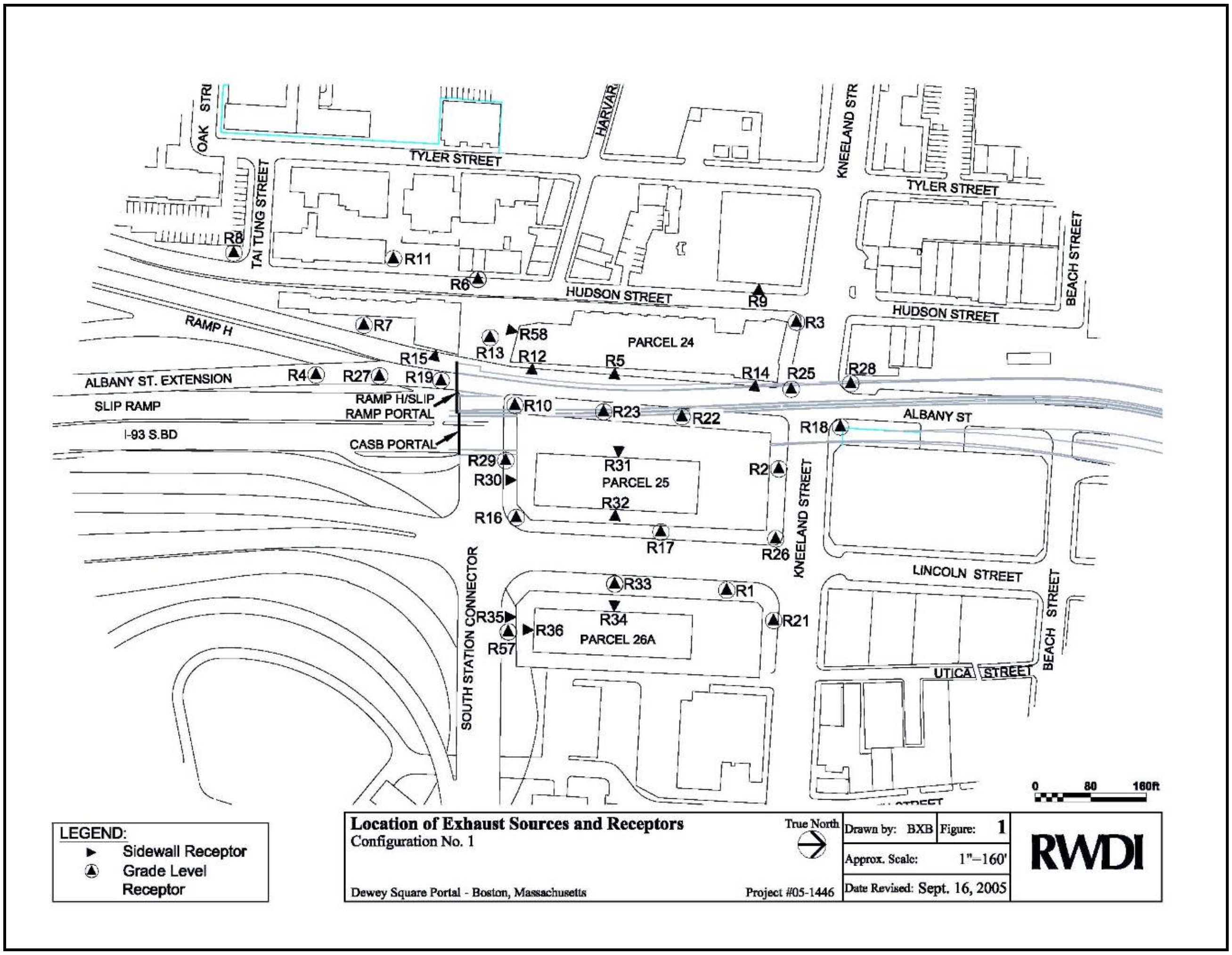


FIGURE 2-16: DEWEY SQUARE TUNNEL – CONFIGURATION 2

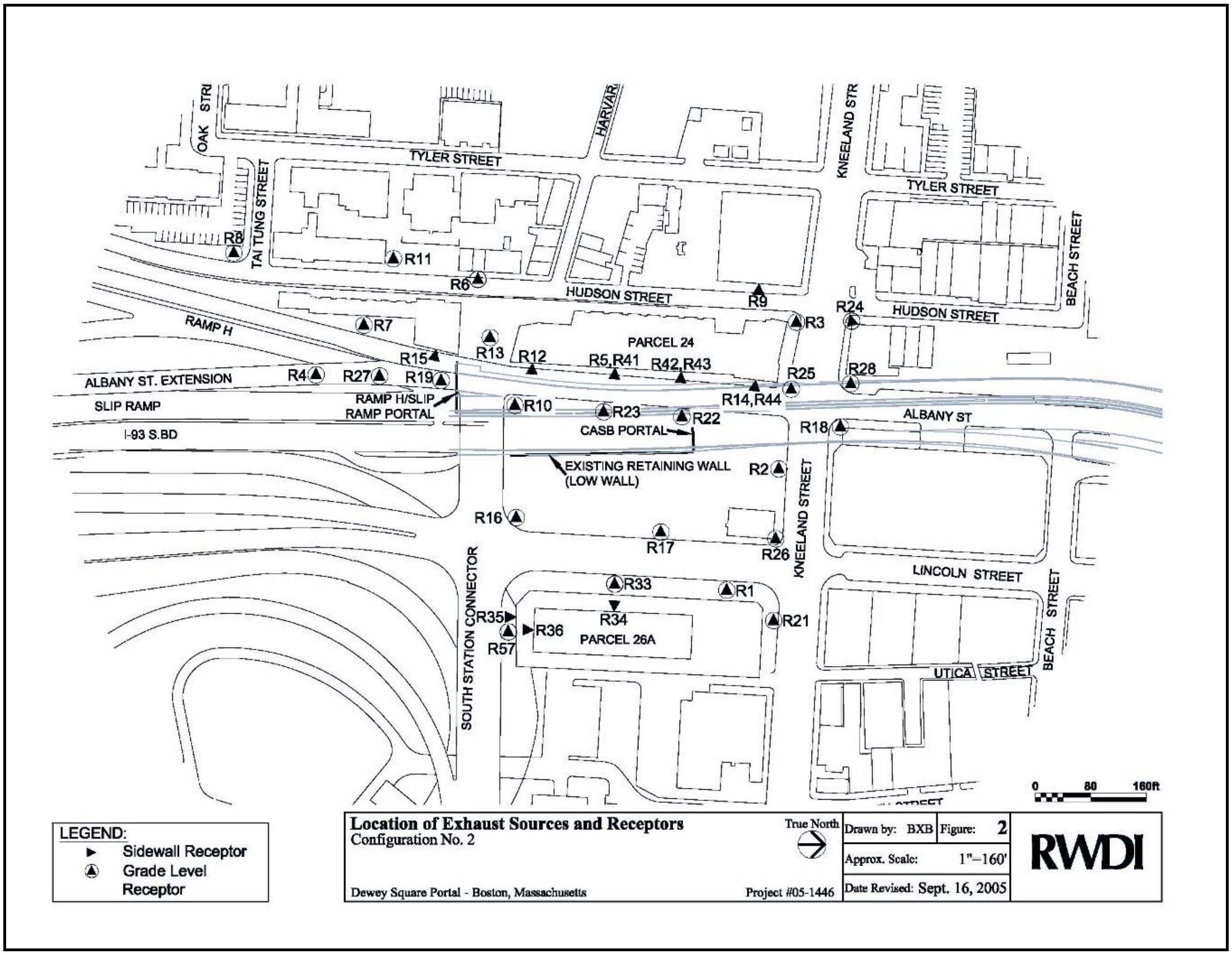
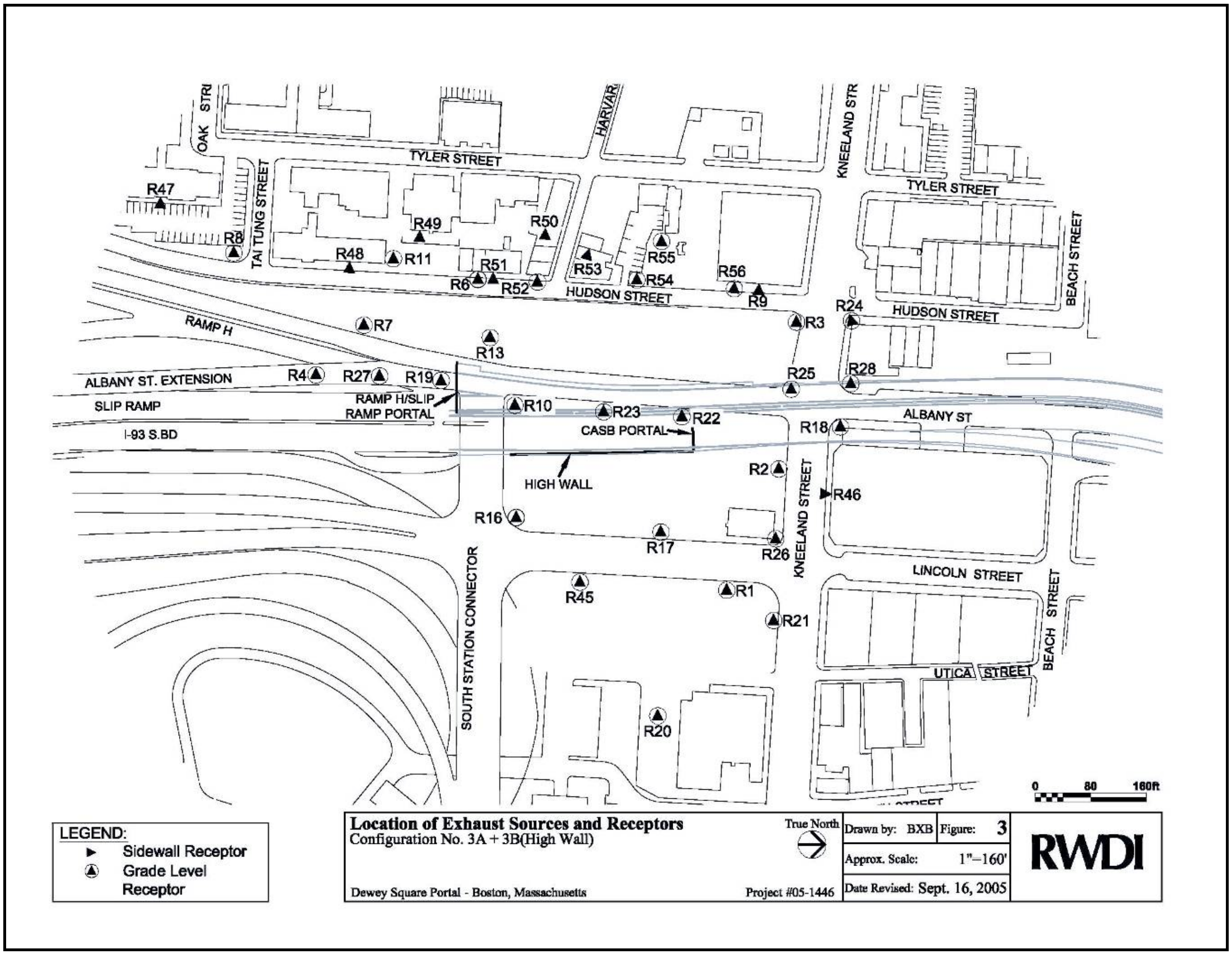


FIGURE 2-17: DEWEY SQUARE TUNNEL – CONFIGURATION 3A



Flow visualization tests were initially performed to determine the most likely location of the highest impacts, and detailed tracer gas tests were performed at the identified high impact locations, including sensitive public areas, and air intakes of the surrounding buildings.

A full description of the study methodology and results was prepared in the final report *Air Quality Study Dewey Square Portal Boston, Massachusetts*, prepared by RWDI, January 2006.

The detailed modeling procedures used for determination of the DST emission impacts and emission limits can be found in Appendix B, "Air Quality Analysis Protocol for Determination of Emission Limits as Part of the Operating Certification of the Project Ventilation Systems" of this document.

2.5.2.2 Use of Physical Simulation Data

The air quality dispersion modeling analysis to determine the emission limits for the longitudinally ventilated ramps and the DST is based on the dilution coefficients obtained through the 1996 physical simulation study for the longitudinally ventilated ramps and through the 2005 DST physical simulation study.

The dilution factors obtained for the three wind speeds and 24 wind angles for each scenario at each receptor location for the longitudinally ventilated ramps were used to create a series of matrices. These matrices provide the tracer gas concentration measured at each receptor location as a percentage of the full concentration measured at the exit portal (this is the dilution ratio).

This dilution ratio was applied to the full scale source concentration for each pollutant analyzed, and interpolated using the five years (2000–2004) of meteorological data in order to obtain the highest and second highest pollutant levels at each receptor location.

The receptor locations were the ambient locations (public access and buildings windows and/or air intake locations) as used in the 1996 and 2005 physical simulation studies. The site plans and receptor locations for each ramp are provided in Figures 2-8 to 2-17.

2.5.2.3 CO Analysis

The CO emission source level for the exit ramps was analyzed in the range from 5 to 70 ppm for each portal. Peak-hour flow conditions (and associated dilution factors) were used for the one-hour analysis, and 8-hour flow conditions (and associated dilution factors)—for the 8-hour analysis. Five years of actual meteorological observations were used to come up with the critical source level at which both one and eight-hour NAAQS is exceeded. The critical source level is identified to the 1 ppm precision. The one and eight-hour emission limits are established as source levels 1 ppm lower than the critical level or the highest levels at which both NAAQS are not potentially exceeded.

An in-house program was created to multiply the emission source level by the dilution factor (from the physical simulation study matrix). This program also interpolates the ratios from the dilution matrix to account for the actual wind speed and direction at each hour of the year from the meteorological data set of 5 years. In addition, the program adds the hourly CO background concentration for the respective hour.

The form of the equation is:

$CO_{\text{(at receptor)}} = CO_{\text{(at source-portal)}} \text{ x Dilution Factor}_{\text{(N hour)}} + CO_{\text{(background N-hour)}}$

$CO_{\text{(at source-portal)}}$ = from 10 to 70 ppm

Dilution Factor $_{\text{(N hour)}}$ = f(Wind Speed, Wind Direction)

N-hour = each hour for the full calendar year

EPA modeling procedures described in Section 9.3.4.2 of the *USEPA Guideline on Air Quality Models (EPA-450/2-78-027R)* were used for calm winds and missing meteorological data. In the case of missing background CO concentration, the program sets the level for that specific hour to zero. This also follows the procedures provided in the reference cited above.

The program output prints the 1st and 2nd highest levels for each source strength for the year indicating the date and hour of occurrence.

Eight-hour analysis procedure is based on the average of eight sequential one-hour results printing the 1st and 2nd non-overlapping highest levels for the year indicating date and the ending hour of the eight-hour period.

Carbon Monoxide 1- and 8-hour levels for NAAQS compliance demonstration are presented in Tables 2-12 through 2-24. These are 2nd highest concentrations. (The use of 2nd highest concentrations follows the EPA requirements for compliance with CO NAAQS.)

TABLE 2-12: 1- AND 8-HOUR CO LEVELS FOR COMPLIANCE DEMONSTRATION: RAMP LC-S

Ramp LC-S									
	One Hour CO				**Eight Hour CO**				
Year	Receptor	Source CO	2nd Highest Level	Date Hour	Receptor	Source CO	2nd Highest Level	Date	Ending Hour
2000	4	70	19.9	11/03/00 19	4	40	8.9	02/18/00	10
2001	4	70	18.9	03/18/01 03	4	41	8.9	08/19/01	8
2002	4	70	19.6	02/10/02 03	4	39	8.8	08/13/02	10
2003	4	70	19.1	05/03/03 22	4	40	8.8	08/29/03	8
2004	4	70	19.0	06/30/04 21	4	41	8.8	11/21/04	18

TABLE 2-13: 1- AND 8-HOUR CO LEVELS FOR COMPLIANCE DEMONSTRATION: RAMP SA-CN

Ramp SA-CN									
	One Hour CO				**Eight Hour CO**				
Year	Receptor	Source CO	2nd Highest Level	Date Hour	Receptor	Source CO	2nd Highest Level	Date	Ending Hour
2000	33	70	8.1	11/09/00 18	33	70	4.7	03/23/00	17
2001	33	70	8.1	07/20/01 11	33	70	4.0	04/25/01	22
2002	33	70	8.1	09/07/02 18	33	70	3.7	02/24/02	20
2003	33	70	8.4	09/08/03 20	33	70	4.7	03/24/03	21
2004	33	70	8.2	03/05/04 18	33	70	3.8	02/20/04	23

TABLE 2-14: 1- AND 8-HOUR CO LEVELS FOR COMPLIANCE DEMONSTRATION: RAMP CN-S

Ramp CN-S									
	One Hour CO				**Eight Hour CO**				
Year	Receptor	Source CO	2nd Highest Level	Date Hour	Receptor	Source CO	2nd Highest Level	Date	Ending Hour
2000	23	70	15.2	09/05/00 22	23	64	8.9	12/16/00	13
2001	23	70	15.0	03/02/01 08	23	59	8.9	12/13/01	10
2002	23	70	14.9	03/13/02 06	23	65	8.970	10/30/02	22
2003	23	70	15.2	12/19/03 20	23	65	8.9	11/27/03	14
2004	23	70	15.0	04/26/04 21	23	58	8.9	11/17/04	10

TABLE 2-15: 1- AND 8-HOUR CO LEVELS FOR COMPLIANCE DEMONSTRATION: RAMP ST-CN NO PARCEL 6

Ramp ST-CN no Parcel 6									
	One Hour CO				Eight Hour CO				
Year	Receptor	Source CO	2nd Highest Level	Date Hour	Receptor	Source CO	2nd Highest Level	Date	Ending Hour
2000	12	70	7.9	11/04/00 01	9	70	6.4	12/04/00	24
2001	12	70	7.4	12/17/01 12	9	70	6.4	12/10/01	10
2002	12	70	7.1	01/26/02 24	9	70	5.6	07/07/02	23
2003	34	70	7.8	12/09/03 17	9	70	5.8	10/30/03	24
2004	12	70	7.0	12/03/04 07	9	70	5.9	01/12/04	24

TABLE 2-16: 1- AND 8-HOUR CO LEVELS FOR COMPLIANCE DEMONSTRATION: RAMP ST-SA NO PARCEL 6

Ramp ST-SA no Parcel 6									
	One Hour CO				Eight Hour CO				
Year	Receptor	Source CO	2nd Highest Level	Date Hour	Receptor	Source CO	2nd Highest Level	Date	Ending Hour
2000	34	70	14.7	11/03/00 19	34	51	8.9	01/02/00	9
2001	34	70	14.3	04/27/01 22	34	56	8.962	10/03/01	9
2002	34	70	13.2	1/27/02 02	34	54	8.975	01/27/02	8
2003	34	70	13.4	07/07/03 22	34	57	8.9	08/29/03	8
2004	34	70	13.5	12/31/04 01	34	60	8.997	11/18/04	8

TABLE 2-17: 1- AND 8-HOUR CO LEVELS FOR COMPLIANCE DEMONSTRATION: RAMP ST-SA + PARCEL 6

Ramp ST-SA + Parcel 6									
	One Hour CO				Eight Hour CO				
Year	Receptor	Source CO	2nd Highest Level	Date Hour	Receptor	Source CO	2nd Highest Level	Date	Ending Hour
2000	34	70	17.3	12/11/00 10	34	48	8.9	01/02/00	9
2001	34	70	17.7	12/05/01 21	34	52	8.963	09/18/01	24
2002	34	70	16.6	10/22/02 24	34	54	8.970	07/27/02	8
2003	34	70	16.3	05/26/03 01	34	51	8.961	12/10/03	9
2004	34	70	16.8	10/13/04 18	34	54	8.975	12/03/04	9

TABLE 2-18: 1- AND 8-HOUR CO LEVELS FOR COMPLIANCE DEMONSTRATION: RAMP CS-SA + PARCEL 12

Ramp CS-SA + Parcel 12									
	One Hour CO				Eight Hour CO				
Year	Receptor	Source CO	2nd Highest Level	Date Hour	Receptor	Source CO	2nd Highest Level	Date	Ending Hour
2000	11	70	23.9	03/23/00 03	11	37	8.998	11/20/00	14
2001	11	70	23.1	01/08/01 10	11	33	8.8	01/14/01	22
2002	11	70	24.2	00/17/02 02	11	38	8.9	07/30/02	8
2003	11	70	23.3	09/16/03 20	11	38	8.8	11/27/03	9
2004	11	70	23.9	01/27/04 17	11	37	8.9	11/18/04	8

TABLE 2-19: 1- AND 8-HOUR CO LEVELS FOR COMPLIANCE DEMONSTRATION: RAMP CS-SA NO PARCEL 12

Ramp CS-SA no Parcel 12									
	One Hour CO				Eight Hour CO				
Year	Receptor	Source CO	2nd Highest Level	Date Hour	Receptor	Source CO	2nd Highest Level	Date	Ending Hour
2000	3	70	18.5	11/04/00 01	3	51	8.9	12/04/00	24
2001	3	70	18.4	04/27/01 22	3	46	8.9	12/17/01	13
2002	3	70	17.5	01/26/02 24	3	51	8.967	07/30/02	8
2003	3	70	17.6	06/07/03 16	3	53	8.9	10/01/03	12
2004	3	70	17.4	01/21/04 15	3	53	8.999	11/18/04	13

TABLE 2-20: 1- AND 8-HOUR CO LEVELS FOR COMPLIANCE DEMONSTRATION: RAMP CS-P

Ramp CS-P									
	One Hour CO				Eight Hour CO				
Year	Receptor	Source CO	2nd Highest Level	Date Hour	Receptor	Source CO	2nd Highest Level	Date	Ending Hour
2000	20	70	15.0	11/19/00 23	20	70	3.5	01/30/00	8
2001	20	70	14.8	05/07/01 07	20	70	3.9	12/10/01	10
2002	20	70	14.8	07/04/02 04	1	70	3.4	07/15/02	18
2003	20	70	14.5	10/01/03 10	19	70	3.4	11/24/03	8
2004	20	70	13.6	04/18/04 02	1	70	3.3	01/04/04	10

TABLE 2-21: 1- AND 8-HOUR CO LEVELS FOR COMPLIANCE DEMONSTRATION: RAMP F

Ramp F									
	One Hour CO				Eight Hour CO				
Year	Receptor	Source CO	2nd Highest Level	Date Hour	Receptor	Source CO	2nd Highest Level	Date	Ending Hour
2000	29	70	11.1	02/26/00 24	22	70	4.7	01/02/00	9
2001	29	70	11.4	01/08/01 13	29	70	7.4	01/08/01	14
2002	29	70	10.8	11/04/02 01	29	70	6.4	11/03/02	22
2003	29	70	10.7	11/18/03 06	29	70	7.3	02/16/03	22
2004	29	70	10.4	03/05/04 01	29	70	7.7	11/16/04	12

TABLE 2-22: 1- AND 8-HOUR CO LEVELS FOR COMPLIANCE DEMONSTRATION – DEWEY SQUARE TUNNEL: CONFIGURATION 1

CONFIG 1									
	One Hour CO				Eight Hour CO				
Year	Receptor	Source CO	2nd Highest Level	Date Hour	Receptor	Source CO	2nd Highest Level	Date	Ending Hour
2000	27	70	29.8	12/19/00 10	4	22	8.8	02/22/00	8
2001	27	70	29.5	07/05/01 01	4	24	8.7	12/10/01	23
2002	27	70	29.7	01/29/02 19	4	24	8.9	11/04/02	24
2003	27	70	29.2	05/25/03 12	4	25	8.9	03/01/01	10
2004	27	70	30.6	08/13/04 03	4	24	8.95	07/01/04	8

TABLE 2-23: 1- AND 8-HOUR CO LEVELS FOR COMPLIANCE DEMONSTRATION – DEWEY SQUARE TUNNEL: CONFIGURATION 2

CONFIG 2									
	One Hour CO				Eight Hour CO				
Year	Receptor	Source CO	2nd Highest Level	Date Hour	Receptor	Source CO	2nd Highest Level	Date	Ending Hour
2000	23	70	27.9	11/03/00 11	4	23	8.8	04/27/00	24
2001	23	70	28.0	1/23/2001 11	4	22	8.7	01/23/01	11
2002	23	70	27.7	01/27/02 02	4	24	8.9	08/22/02	8
2003	23	70	27.9	12/03/03 21	4	24	8.95	06/07/03	8
2004	23	70	27.7	11/17/04 21	4	23	8.8	07/01/04	8

TABLE 2-24: 1- AND 8-HOUR CO LEVELS FOR COMPLIANCE DEMONSTRATION – DEWEY SQUARE TUNNEL: CONFIGURATION 3A

CONFIG 3A									
	One Hour CO				Eight Hour CO				
Year	Receptor	Source CO	2nd Highest Level	Date Hour	Receptor	Source CO	2nd Highest Level	Date	Ending Hour
2000	4	70	28.4	03/23/00 21	4	24	8.98	02/18/00	10
2001	4	70	26.9	02/14/01 04	4	23	8.7	01/23/01	11
2002	4	70	27.5	09/06/02 22	4	24	8.8	06/17/02	8
2003	4	70	26.9	12/09/03 21	4	24	8.8	12/09/03	24
2004	4	70	26.9	11/18/04 19	4	24	8.8	10/08/04	9

2.5.2.4 NO_2 Analysis

The NO_x levels at the ramp exit portals were estimated using the equations 1 through 3 from Section 2.4.3 and 2.4.4. The estimated NO_x source levels varied from 0.82 to 8.88 ppm as the source CO levels varied from 5 to 70 ppm.

The Ozone Limiting Method (OLM) was utilized to determine the critical concentrations. Peak-hour flow conditions (and associated dilution factors) were used to estimate one-hour impacts. Five years of actual background measurements of NO_2 and O_3 concentrations at Roxbury and East Boston were used in the analysis. Five years of actual meteorological observations at Logon International Airport were also used in the analysis. The critical source level is identified to the 1 ppm CO precision. The one-hour emission limit is established as a CO source level 1 ppm lower than the critical level. The critical level is the highest level at which the Mass DEP Guideline Concentration is not exceeded.

A program was developed to perform the OLM analysis. This program determines the NO_2 level that is exhausted from the tunnel and multiplies it by the dilution factor (from the physical simulation study matrix) to estimate concentrations at the sensitive receptors. It interpolates the ratios from the dilution factor matrix to account for the actual wind speed and direction at each hour of the year from the meteorological data set of 5 years. Calm conditions and missing data are treated in the same fashion as described in CO analysis procedures.

The program outputs the 1st and 2nd highest levels for the year and for each emission source strength analyzed and indicates the date and hour of occurrence. If the level for a specific hour exceeds the Mass DEP Guideline level, the background ozone and NO_2 concentrations for this hour are also printed.

One-hour Mass DEP NO_2 guideline level of 0.17 ppm was not exceeded at the portals of the longitudinally ventilated ramps and the DSTs as shown in Tables 2-25 through 2-37:

TABLE 2-25: 1-HOUR NO_2 LEVELS FOR COMPLIANCE DEMONSTRATION: RAMP LC-S

Ramp LC-S						
Year	Receptor	Source CO	Source NO_x	2nd Highest NO_2	Date	Hour
2000	4	70	8.88	0.167	09/20/00	15
2001	4	70	8.88	0.160	03/18/01	3
2002	4	69	8.75	0.169	08/13/02	6
2003	4	52	6.64	0.169	06/25/03	18
2004	4	70	8.88	0.156	05/06/04	18

TABLE 2-26: 1-HOUR NO_2 LEVELS FOR COMPLIANCE DEMONSTRATION: RAMP SA-CN

Ramp SA-CN						
Year	Receptor	Source CO	Source NO_x	2nd Highest NO_2	Date	Hour
2000	33	70	8.88	0.115	06/20/00	19
2001	33	70	8.88	0.130	08/09/01	22
2002	33	70	8.88	0.142	08/13/02	10
2003	33	70	8.88	0.136	06/26/03	16
2004	33	70	8.88	0.120	06/08/04	13

TABLE 2-27: 1-HOUR NO_2 LEVELS FOR COMPLIANCE DEMONSTRATION: RAMP CN-S

Ramp CN-S						
Year	Receptor	Source CO	Source NO_x	2nd Highest NO_2	Date	Hour
2000	23	70	8.88	0.153	06/01/00	18
2001	23	70	8.88	0.154	11/23/01	7
2002	23	70	8.88	0.158	08/13/02	17
2003	23	66	8.38	0.169	06/26/03	19
2004	23	70	8.88	0.134	04/18/04	5

TABLE 2-28: 1-HOUR NO_2 LEVELS FOR COMPLIANCE DEMONSTRATION: RAMP ST-CN NO PARCEL 6

Ramp ST-CN no Parcel 6						
Year	Receptor	Source CO	Source NO_x	2nd Highest NO_2	Date	Hour
2000	9	70	8.88	0.118	06/10/00	15
2001	9	70	8.88	0.138	08/09/01	21
2002	9	70	8.88	0.142	08/13/02	18
2003	9	70	8.88	0.134	06/27/03	14
2004	9	70	8.88	0.123	06/08/04	22

TABLE 2-29: 1-HOUR NO_2 LEVELS FOR COMPLIANCE DEMONSTRATION: RAMP ST-SA NO PARCEL 6

Ramp ST-SA no Parcel 6						
Year	Receptor	Source CO	Source NO_x	2nd Highest NO_2	Date	Hour
2000	34	70	8.88	0.157	06/20/00	24
2001	34	70	8.88	0.139	08/09/01	21
2002	34	70	8.88	0.154	08/13/02	17
2003	34	70	8.88	0.160	06/25/03	17
2004	34	70	8.88	0.127	03/26/04	6

TABLE 2-30: 1-HOUR NO_2 LEVELS FOR COMPLIANCE DEMONSTRATION: RAMP ST-SA + PARCEL 6

Ramp ST-SA + Parcel 6						
Year	Receptor	Source CO	Source NO_x	2nd Highest NO_2	Date	Hour
2000	34	70	8.88	0.168	06/09/00	24
2001	34	70	8.88	0.162	12/05/01	18
2002	34	70	8.88	0.167	08/13/02	3
2003	34	70	8.88	0.167	06/27/03	2
2004	34	70	8.88	0.143	07/21/04	23

TABLE 2-31: 1-HOUR NO_2 LEVELS FOR COMPLIANCE DEMONSTRATION: RAMP CS-SA + PARCEL 12

Ramp CS-SA + Parcel 12						
Year	Receptor	Source CO	Source NO_x	2nd Highest NO_2	Date	Hour
2000	11	50	6.4	0.168	06/21/00	1
2001	11	44	5.65	0.169	05/02/01	13
2002	11	51	6.52	0.168	03/31/02	1
2003	11	51	6.52	0.169	06/25/03	18
2004	11	62	7.88	0.169	01/27/04	17

TABLE 2-32: 1-HOUR NO_2 LEVELS FOR COMPLIANCE DEMONSTRATION: RAMP CS-SA NO PARCEL 12

Ramp CS-SA no Parcel 12						
Year	Receptor	Source CO	Source NO_x	2nd Highest NO_2	Date	Hour
2000	3	60	7.64	0.169	06/20/00	24
2001	3	56	7.14	0.169	05/02/01	13
2002	3	66	8.38	0.169	08/13/02	9
2003	34	63	8.01	0.169	06/26/03	18
2004	33	70	8.88	0.156	06/08/04	22

TABLE 2-33: 1-HOUR NO_2 LEVELS FOR COMPLIANCE DEMONSTRATION: RAMP CS-P

Ramp CS-P						
Year	Receptor	Source CO	Source NO_x	2nd Highest NO_2	Date	Hour
2000	20	70	8.88	0.134	02/15/00	24
2001	1	70	8.88	0.140	06/20/01	11
2002	1	70	8.88	0.150	08/13/02	17
2003	1	70	8.88	0.139	01/01/00	1
2004	1	70	8.88	0.123	06/08/04	22

TABLE 2-34: 1-HOUR NO_2 LEVELS FOR COMPLIANCE DEMONSTRATION: RAMP F

Ramp F						
Year	Receptor	Source CO	Source NO_x	2nd Highest NO_2	Date	Hour
2000	29	70	8.88	0.114	09/09/00	11
2001	15	70	8.88	0.132	08/09/01	22
2002	22	70	8.88	0.141	08/13/02	18
2003	22	70	8.88	0.134	06/26/03	17
2004	29	70	8.88	0.12	05/12/04	21

TABLE 2-35: 1-HOUR NO_2 LEVELS FOR COMPLIANCE DEMONSTRATION: DEWEY SQUARE TUNNEL – CONFIGURATION 1

Dewey Square Tunnel CONFIG 1						
Year	Receptor	Source NO_x	Source CO	2nd Highest NO_2	Date	Hour
2000	27	4.54	35	0.162	07/02/00	16
2001	27	3.3	25	0.165	06/20/01	13
2002	27	2.92	22	0.169	08/13/02	16
2003	27	3.3	25	0.169	06/27/03	12
2004	27	4.54	35	0.162	07/30/04	15

TABLE 2-36: 1-HOUR NO_2 LEVELS FOR COMPLIANCE DEMONSTRATION : DEWEY SQUARE TUNNEL – CONFIGURATION 2

Dewey Square Tunnel CONFIG 2						
Year	Receptor	Source NO_x	Source CO	2nd Highest NO_2	Date	Hour
2000	23	4.54	35	0.166	07/03/00	4
2001	23	2.92	22	0.168	08/03/01	17
2002	19	2.8	21	0.168	08/13/02	16
2003	23	3.3	25	0.169	07/04/03	23
2004	23	3.92	30	0.169	06/08/04	22

TABLE 2-37: 1-HOUR NO_2 LEVELS FOR COMPLIANCE DEMONSTRATION : DEWEY SQUARE TUNNEL – CONFIGURATION 3A

Dewey Square Tunnel CONFIG 3A						
Year	Receptor	Source NO_x	Source CO	2nd Highest NO_2	Date	Hour
2000	4	4.54	35	0.168	06/20/00	23
2001	19	4.54	35	0.168	06/20/01	13
2002	19	3.3	25	0.169	08/13/02	16
2003	4	4.54	35	0.169	06/27/03	2
2004	19	5.16	40	0.163	07/30/04	15

2.5.3 VOC Emission Limit Determination

The effects of the CA/T Project on VOC regional levels is based on an estimation of the 2005 transportation related VOC emissions (highway and transit) for the area affected by the CA/T Project for both the CA/T and No-Build conditions.

2.5.3.1 Travel Demand Model

The travel model used for the CA/T Project VOC Analysis is based on procedures and data that have evolved over many years. The model set is of the same type as those used in most large urban areas in North America. It is based on the traditional four-step urban transportation planning process of trip generation, trip distribution, mode choice, and trip assignment. A description of the modeling process can be found in Appendix B, “Air Quality Analysis Protocol for Determination of Emission Limits as Part of the Operating Certification of the Project Ventilation Systems” of this document.

The Central Transportation Planning Staff (CTPS) model area encompasses 164 cities and towns in Eastern Massachusetts, as shown in Figure 2-18~~Figure 2-18~~ The CA/T Project area is shown in Figure 2-19~~Figure 2-19~~. The modeled area is divided into 986 internal Traffic Analysis Zones (TAZs). There are 101 external stations around the periphery of the modeled area that allow for travel between the modeled area and adjacent areas of Massachusetts, New Hampshire and Rhode Island.

The model set simulates travel on the entire Eastern Massachusetts transit and highway system. It contains all Massachusetts Bay Transportation Authority (MBTA) rail and bus lines and all private express bus carriers. The model contains service frequency, routing, travel time and fares for all these lines. In the highway system, all express highways and principle arterial roadways, and many minor arterial and local roadways are included.

A Network was prepared by CTPS to include the Central Artery, as it existed prior to construction of the CA/T Project. A list of projects included in the No-Build network is shown in Table 2-38. Next, a future Build network was developed that includes the CA/T Project in full operation, along with the transit projects that were included in the State Implementation Plan. A list of those projects is also included in Table 2-38. Certain transit projects have been delayed, including Blue Line Platform Lengthening, Blue Line/Red Line Connector, Green Line Extension to Medford Hills, the Old Colony Commuter Rail extension to Greenbush, and additional Orange Line vehicles, and have been addressed in the 2002 and 2005 Amendments to the ACO. None of these delayed transit projects were included in the 2005 Build and No-Build Network. It is worth noting, however, that even though these delayed transit projects have not been included, the CA/T air quality analysis performed for the Operating Certification demonstrated that based on most current traffic data and emission analysis, the operation of the CA/T Project's tunnel ventilation system does not cause or result in a violation of any of the certification criteria set forth in the Ventilation Certification Regulation.

2.5.3.2 Procedures for Highway Network VOC Analysis

The air quality effects of regional VOC levels of the two transportation scenarios (2005 CA/T Project Build and No-Build) was analyzed using the travel demand model previously described. From the highway assignment component of the model, traffic volumes, average highway speeds, vehicle miles and vehicle hours traveled were estimated. The amount of VOC emitted by the highway traffic depends on the prevailing highway speeds and vehicle miles traveled on the network. The CTPS model uses MOBILE 6.2 emission factors to calculate VOC (and also CO and NO_x) on a link-by-link basis based on the congested speed and vehicle miles of travel.

There are other transportation related components contributing to VOC emissions, which cannot be handled directly within the model. These are:

- The pollutants emitted by the Diesel Locomotives of the Commuter rail system
- The pollutants emitted by the MBTA bus system
- The pollutants emitted by the commuter ferries

The pollutants from the categories above can be estimated outside of the model and included with the vehicular emissions calculated within the model. The following paragraphs describe the general off-model procedure that will be used to handle these categories.

FIGURE 2-18: CTPS MODELED AREA

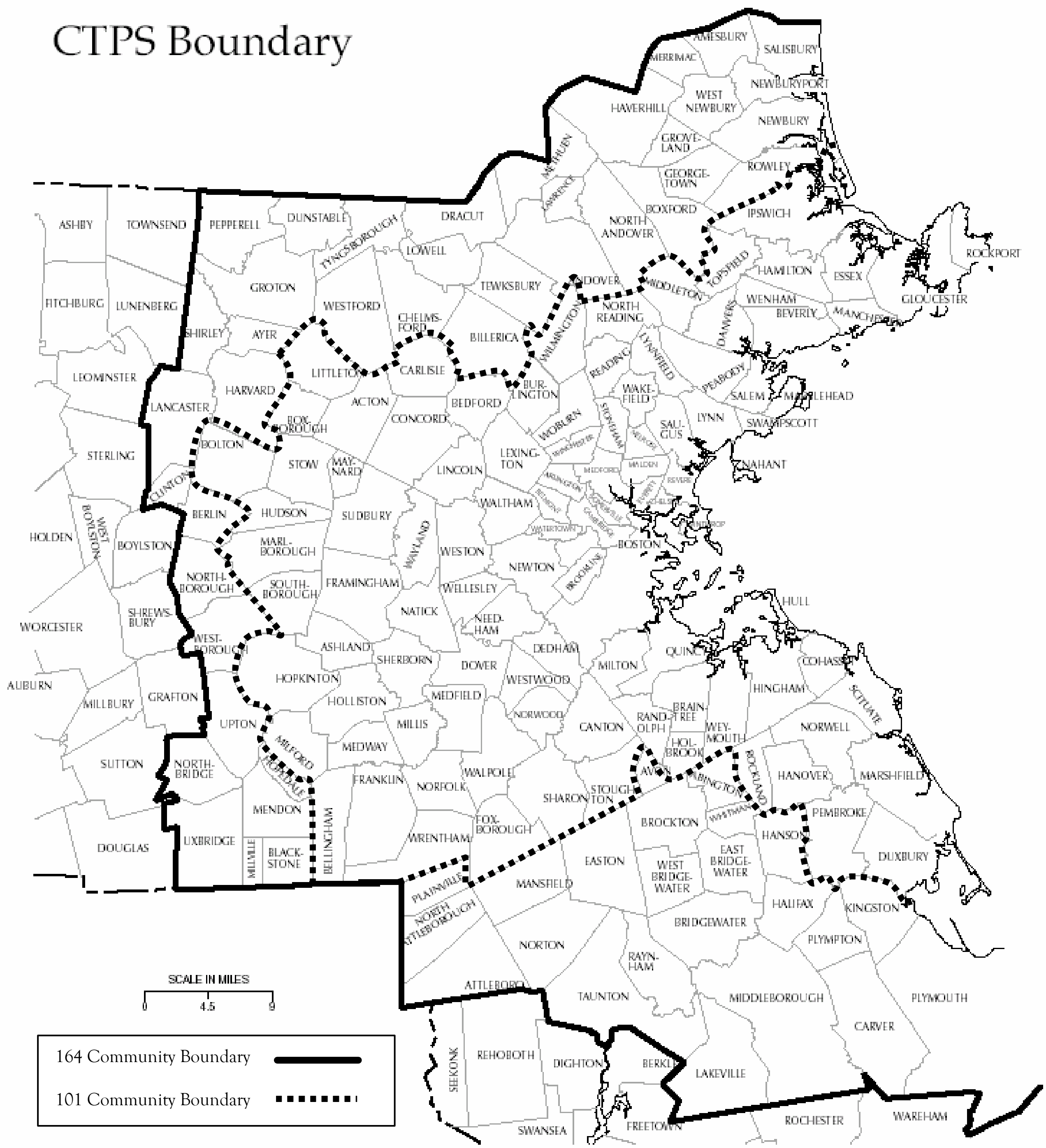


FIGURE 2-19: CA/T PROJECT STUDY AREA

TABLE 2-38: PROJECTS INCLUDED IN THE BUILD AND NO-BUILD NETWORKS

Projects	No-Build	Artery Build
Highway		
Route 53, Phase I (Hanover)	X	X
Blue Hill Avenue Signal Coordination	X	X
Brighton Avenue Signal Coordination	X	X
Marrett Road Signal Coordination	X	X
Beverly Salem Bridge	X	X
Route 20, Segment 1 (Marlborough)	X	X
Route 20, Segments 2 & 3 (Marlborough)	X	X
I-495 interchange (Marlborough/Southborough)	X	X
I-93/Industriplex Interchange (Woburn)	X	X
Quincy Center Concourse, Phase I (Quincy)	X	X
Route 62 and Middlesex Turnpike (Burlington)	X	X
Route 9 (Wellesley)	X	X
Route 138 (Canton)	X	X
Bridge Street – Boston to Flint (Salem)	X	X
Massachusetts Avenue/Lafayette Square, (Cambridge)	X	X
Cambridgeport Roadways	X	X
I-95 (SB)/Dedham Street Onramp (Canton)	X	X
Route 140 (Franklin)	X	X
Route 139 (Marshfield)	X	X
Route 38 (Wilmington)	X	X
Route 1 and Associated Improvements (Foxborough)	X	X
Route 3 North	X	X
Central Artery		X
Ted Williams Tunnel		X
South Boston Bypass Road (aka/Haul Road)		X
Leverett Circle Bridge (Charlestown)		X
HOV Lane on I-93 (Mystic Avenue)		SIP
HOV Lane on the Southeast Expressway		SIP
Transit		
Amtrak Northeast Corridor Electrification	X	X
Route 128 Amtrak Station	X	X
AMTRAK Service to Portland, Maine	X	X
Mattapan Refurbishment	X	X
Industriplex Intermodal Center (Woburn)	X	X
Airport Intermodal Transit Connector	X	X
Urban Ring bus service (CT1, CT2, CT3)		CAT/SIP study
Additional Park and Ride Spaces		SIP/CAT/ACO
South Station Transportation Center		SIP/CAT
Commuter Boat Service in the Inner Harbor		CAT

TABLE 2-38: PROJECTS INCLUDED IN THE BUILD AND NO-BUILD NETWORKS (CONTINUED)

Projects	No-Build	Artery Build
Newburyport Commuter Rail Service		SIP/CAT
Old Colony Commuter Rail (two lines)		SIP/CAT
Worcester Commuter Rail, full service		SIP/CAT
Worcester Commuter Rail, new stations		ACO
Silver Line – Transitway, Phase 1		SIP/CAT/ACO
Silver Line – Washington Street, Phase 2		CAT/ACO
Low Emission Buses		ACO
North Station Improvements		SIP/CAT
Bus Service Improvements to the North Shore		Substitute
Hingham Ferry		Substitute
Improved service on the Haverhill Commuter Rail Line		Substitute
New Commuter Rail Station at JFK/UMASS Station		Substitute

Notes:
SIP – Project included in the Transit System Improvements Regulation of the SIP
CAT – Project included in the Certification of Tunnel Ventilation Systems Regulation
ACO – Project included in the Administrative Consent Order
Substitute – Project approved as a substitute to the Old Colony Greenbush project
Delayed transit projects including Blue Line Platform Lengthening, Blue Line/Red Line Connector, Green Line Extension to Medford Hills, the Old Colony Commuter Rail extension to Greenbush, and additional Orange Line vehicles were not included in the Build and No Build Network.

2.5.3.3 Procedure for Off- Model VOC Analysis

Commuter Rail Diesel Locomotives

The CTPS approach involved the following steps.

- Obtain the current train-miles run by the MBTA per day.
- Based on the MBTA's future service plan, estimate the number of train-miles to be run per day for 2005 on all the existing rail lines as well as on all future extensions and new services such as the Old Colony lines.

Using the emission factors developed by the EPA, and the number of train-miles, the amount of VOC emitted by the commuter rail system were estimated for 2005. The emission factors developed by the EPA are based on the total diesel fuel consumption by the entire MBTA's commuter rail system. Therefore, the pollutants emitted during the long idling periods have also been figured into the calculations.

MBTA'S Diesel & CNG Buses

The bus emissions were calculated in the same way as the commuter trains but with an emission factor specific to the bus fuel type. The bus emission factors for 2005 were calculated from the MBTA's future plans regarding the vehicle procurement rate, vehicle replacement rate and the fleet composition.

Commuter Ferries

The daily VOC were estimated based on fuel consumption supplied by the ferry operators, and the EPA pollutant emission factors for marine gas and diesel engines. It was assumed that one third of the fuel consumption of the whole Metropolitan Planning Organization (MPO) area occurs within the CA/T Project area.

2.5.4 VOC Analysis

The results of the VOC regional analyses are presented for three different scales: Eastern Massachusetts Regional Planning Area (EMRPA) 164 community boundary, the MPO 101 community boundary, and the CA/T Project area.

Tables 2-39 to 2-42 provide the daily VMT and VOCs for the vehicular network and the off-network MBTA buses, commuter railroad and ferries. It is important to notice that the CA/T Project results in significant reductions on VMT and VOCs at the motor vehicle network level, and increases in the public transit off-network analysis. This is a direct result of a reduction on motor vehicle travel and an increase in transit service.

TABLE 2-39: NETWORK-BASED DAILY VMT (VEHICLES MILES TRAVELED) AND VOCS (KG/DAY)

Region	No Build		CA/T Build		Reductions	
	VMT	VOC	VMT	VOC	VMT	VOC
EMRPA	122,409,896	91,157	121,016,208	81,734	1,393,688	9,424
MPO	88,099,325	66,696	86,877,467	59,499	1,221,858	7,198
CA/T	7,810,659	6,913	7,767,266	5,909	43,393	1,004

TABLE 2-40: MBTA BUSES DAILY VMT AND VOCS (KG/DAY)

Region	No Build		CA/T Build		Increments	
	VMT	VOC	VMT	VOC	VMT	VOC
EMRPA	85,687	3.3	88,628	52.1	2,941	48.8
MPO	85,647	3.3	88,588	52.1	2,942	48.8
CA/T	7,060	0.4	10,001	8.2	2,941	7.8

TABLE 2-41: COMMUTER RAILROAD DAILY VMT AND VOCS (KG/DAY)

Region	No Build		CA/T Build		Increments	
	VMT	VOC	VMT	VOC	VMT	VOC
EMRPA	12,822	493	15,509	597	2,687	103
MPO	10,249	394	11,560	445	1,311	50
CA/T	1,148	44	1,258	48	110	4

TABLE 2-42: FERRY DAILY FUEL CONSUMPTION AND VOCS (KG/DAY)

Region	No Build		CA/T Build		Increments	
	Fuel (gallons)	VOC	Fuel (gallons)	VOC	Fuel (gallons)	VOC
EMRPA	3,493	285.8	4,793	392.2	1,300	106.4
MPO	3,493	285.8	4,793	392.2	1,300	106.4
CA/T	1,164	95.3	1,598	130.7	433	35.5

Table 2-43 provides the total cumulative (motor vehicle and transit) VMT and VOC which results in a net reduction of VOC with the CA/T Project and transit commitments.

TABLE 2-43: TOTAL DAILY VOC EMISSIONS (KG/DAY)

Region	No Build	CA/T Build	Reductions
EMRPA	91,939.9	82,775.3	9,163.8
MPO	67,379.9	60,388.3	6,990.8
CA/T	7,052.7	6,095.9	956.7

The results (provided in Table 2-43) demonstrate that the CA/T Project result in a reduction of VOC within the Project affected area when compared to the No-Build condition for all regional scales analyzed. As anticipated, the highest percentage reduction (13.6%) is for the CA/T Project area, and the lowest (10%) is for the EMRP area.

2.6 PROPOSED OPERATING EMISSION LIMITS

The proposed operating emission limits are based on the compliance modeling and demonstration of compliance to the applicable standards at the emission limits as described above.

2.6.1 Full-Transverse Ventilation

In summary, the VB modeling results presented in this document are based on a set of hypothetical tunnel operating conditions. Although this hypothetical operating scenario was intentionally set at the highest pollution levels, the emission impact modeling results indicated that operation of the CA/T VBs will not cause or exacerbate a violation of the applicable NAAQS for CO, NO_2 and PM_{10} and the Mass DEP Policy Guideline Value for NO_2.

In order to allow for traffic growth in the tunnels and also to provide flexibility in operating the tunnel ventilation system, the hypothetical tunnel operating conditions analyzed are proposed to be adopted as the VB operating emission limits as follows:

TABLE 2-44: OPERATING LIMITS FOR VENTILATION BUILDINGS

Regulated Pollutant	Time Period	Hourly Emission Limits (for All VBs)
CO	One and eight hours	70.00 ppm
NO_x	One hour	8.88 ppm
PM_{10}	24-hour	500 $\mu g/m^3$

2.6.2 Longitudinally-Ventilated Exit Ramps and DST

TABLE 2-45: OPERATING LIMITS FOR LONGITUDINALLY –VENTILATED RAMPS

Longitudinally Ventilated	One-Hour		Eight-Hour
Ramps	Source Level CO	Source Level NO_x	Source Level CO
	ppm	ppm	ppm
LC-S	52	6.64	39
SA-CN	70	8.88	70
CN-S	66	8.38	58
ST-CN no Parcel 6	70	8.88	70
ST-SA + Parcel 6	70	8.88	48
ST-SA no Parcel 6	70	8.88	51
CS-SA + Parcel 12	44	5.65	33
CS-SA no Parcel 12	56	7.14	46
CS-P	70	8.88	70
F	70	8.88	70
DST Configuration 1 (Full Build)	22	2.92	22
DST Configuration 2 (Partial Build)	22	2.92	23
DST Configuration 3A (Existing)	25	3.30	23

2.6.3 VOC

The results of the regional modeling demonstrate that the CA/T Project results in a reduction of VOC within the Project affected area when compared to the No-Build condition for all regional scales analyzed. As anticipated, the highest percentage reduction (13.6%) is for the CA/T Project area, and the lowest (10%) is for the EMRP area.

Based on this analysis the VOC for the CA/T Build condition – **6,095.9 Kg/day** – should be used as a budget limit not to be exceeded in the future years.

2.7 OPERATING CERTIFICATION CRITERIA

In summary, the data collected for the Operating Certification to date demonstrates that the operation of the CA/T Project, as currently constructed and operated, complies with 310 CMR 7.38(2) (a)-(c) in that the CA/T project does not cause or exacerbate a violation of the applicable NAAQS for CO, NO_2 and PM_{10} and the Mass DEP Policy Guideline Value for NO_2 and does not result in an actual or projected increase in the total amount of non-methane hydrocarbons estimated within the project area when compared with the No Build alternative.

Part II – Compliance Monitoring Program

3 PROJECT COMPLIANCE MONITORING SYSTEM

3.1 MASS DEP 310 CMR 7.38(8) REGULATORY REQUIREMENTS

Mass DEP Regulation 310 CMR 7.38(8) states the following requirements for vehicle emissions and vehicle traffic monitoring.

Emissions Monitoring

(a) "Any person who constructs and operates a tunnel ventilation system which is subject to the requirements of 310 CMR 7.38 shall, prior to commencing operation of the tunnel ventilation system or opening the project roadway for public use, develop and submit to the Department for review and approval an "Air Emissions Monitoring Protocol" and shall install and operate emissions monitoring and recording equipment in accordance with the approved protocol. Monitoring as approved by the Department shall be required at the exhaust stacks or exhaust plenums of VBs as well as at exit portals that utilize longitudinal ventilation. The Department will consider for approval hybrid monitoring systems that incorporate elements of the federal regulations for monitoring ambient air pollution, for monitoring stationary source emissions, and for pollutant emission trading (i.e., 40 CFR Parts 58, 60, and 75) as practicable, as well as statistical analysis, computer modeling, and innovative technologies. The "Air Emissions Monitoring Protocol" may also be modified with prior written approval of the Department."

Traffic Monitoring

(b) "Any person who constructs and operates a tunnel ventilation system which is subject to the requirements of 310 CMR 7.38 shall install, operate and maintain traffic monitoring equipment within the project area, the numbers and locations of which shall be determined in consultation with the Department."

3.2 EMISSIONS MEASUREMENT METHODOLOGIES

3.2.1 Applicability of 40 CFR Parts 58, 60 and 75

Unlike emissions from stacks at a power plant, the emissions from the CA/T's ventilation system is unique in that the system contains multiple exhaust stacks and portal emission sources that operate at multiple exhaust flow rates that move extremely large volumes of air. In addition, unlike the emissions from a power plant which emit much higher (i.e., greater) levels of pollutants, pollutant emission levels from any CA/T VB or longitudinally ventilated exit ramp, are much lower. The CEM system described in this section, is considered a hybrid type of system, which uses elements of both ambient air quality monitoring systems and continuous emission monitoring equipment required at power plants. As such, the CA/T's CEM system incorporates various elements of the federal regulations 40 CFR Parts 58, 60, and 75 as well as statistical analysis, computer modeling, and innovative technologies.

3.3 CONTINUOUS EMISSIONS MONITORING SYSTEMS DESCRIPTION

3.3.1 Monitoring Locations for Ventilation Buildings

The pollutant levels are measured at the discharge points for each ventilation zone. Since each exhaust fan has its own exhaust stack, there are more stacks than ventilation zones for each VB. In general each ventilation zone feeds two or three exhaust fans (depending on air flow to be delivered). As examples: there are six exhaust stacks at VB 6 serving two ventilation zones; and 14 stacks at VB 7 serving five ventilation zones. This duplication provides redundancy and sufficient ventilation capacity during the times when fans have to be taken out of service due to maintenance or repairs.

The number of exhaust fans in operation at a given time depends on the control of airflow to and from various section of the tunnel. This is accomplished by the ventilation control system. The amount of ventilation depends on the in-tunnel CO measurements, which are dependent on the traffic characteristics. As such, the amount of the airflow exhausted through each stack could vary from zero to full exhaust capacity depending on the number of operating fans.

In general, there are always some fans in stand-by mode. Therefore, it was not considered cost effective to install equipment to continuously monitor emission levels at each stack, when only some are in simultaneous operation. Instead, vehicular emissions in the tunnel are monitored in the exhaust plenums of each ventilation zone prior to being diverted up and out of the building stacks. This captures the totality of exhaust emissions before they are diverted into a particular stack.

The CO monitoring system employs a "rake probe" to gather the samples. The probe consists of a length of one half inch Teflon or stainless steel tubing. Each of the probes had 8 equal distant holes drilled so that they allowed for sample collection along the entire width of the ventilation plenum. The probe is oriented so that the 8 holes are directed into the direction of flow of the source stream.

The PM_{10} monitoring system also is deployed at the exhaust plenums, but has a single inlet probe at the center of each exhaust plenum. Tests performed during 2003/04 with multiple portable MiniVOL samplers indicated minimum variation of PM_{10} levels across the plenum cross section.

3.3.2 Monitoring Locations for Longitudinal Ventilation

The plume of air that escapes from these tunnels in the wake of exiting traffic maintains its integrity for a distance downstream of the exit portal due to the momentum created by the moving cars. Due to the well mixed turbulence of this plume, the pollutant concentrations inside a cross section of these ramps are fairly uniform.

The CO monitoring system employs a similar "rake probe" with eight equal distant holes to gather the samples. Such probe is located across the roadway at the tunnel ceiling level approximately 100 feet inside each exit portal (Figure 3-1). These measurements provide an average of the in-tunnel CO levels before exiting to the atmosphere.

A CEM PM_{10} monitoring system is also deployed just outside the east portal of longitudinally ventilated exit ramp CS-SA. This monitor measures ambient PM_{10} concentrations in the vicinity of ramp CS-SA.

3.3.3 CO Monitoring System

The CEM equipment used to measure and/or record CO levels is described below. The tunnel ventilation CO monitoring system is independent of the CEM monitoring system. The tunnel ventilation monitoring system is used to maintain safe air quality and visibility within the tunnels and to control smoke and heat in emergencies.

Figure 3-1: CO Ceiling Monitoring Probe at DST

3.3.3.1 Ventilation Buildings and Longitudinally Ventilated Exit Ramps

The CO CEM systems located at VBs 1, 3, 4, 5, 6 and 7 and longitudinal ventilated exit Ramps L-CS, CN-S, SA-CN, CS-SA, ST-SA/ST-CN, CS-P, DST-I93, DST-I-90 and F, consists of the following equipment:

- Non-Dispersive Infrared Continuous CO Gas Analyzer with a detection range of 0 parts per million to 150 parts per million,
- Multi-Gas Calibration System,
- Zero Air Generator,
- System Controller/Data Logger,
- CO Calibration Gas - RATA Class.

3.3.3.2 CEM Equipment Housing

All CEM equipment located at the CA/T VBs are rack mounted in NEMA certified 12 enclosures (Figure 3-2). CEM equipment located in applicable roadway utility rooms for longitudinally ventilated exit ramps are rack mounted in NEMA certified 4x enclosures (Figure 3-3).

Figure 3-2: CO and PM_{10} Monitoring Units at VB 7 Exhaust

Figure 3-3: CO Monitors Longitudinally for Ventilated Tunnels

3.3.3.3 Sample Probe / Sample Transport / Sample Conditioning

The sample probe for the CO emissions monitoring system for both VBs and longitudinally ventilated exit ramps are constructed of stainless steel tubing. The sample probe is installed across each applicable VB's exhaust plenum and in the ceiling of longitudinally ventilated exit ramps in a location so that it is positioned in the stream of air being exhausted through the plenum prior to being diverted up each vent building exhaust stack or out the exit portal of a longitudinally ventilated exit ramp. The probe has eight 1/8-inch diameter holes drilled into it at equal distances along the entire length of the probe. There are no sampling holes located within 3 feet of any exhaust plenum or exit ramp wall. Each sample line is positioned in the exhaust plenum perpendicular to the direction of airflow in the plenum, which ensures that the full cross-sectional airflow within an exhaust plenum is being sampled.

The calibration system that is used to calibrate each CO analyzer uses cylinders of CO gas and a "zero" air source. The CO calibration gas used has been certified according to the EPA RATA procedures. The "zero" air source uses a zero air generator. Zero air and CO gas is diluted using a multi-gas calibration system. The calibration system is capable of controlling and mixing the CO calibration gas stream with the zero air stream to produce concentrations over the entire range of the analyzer. The calibration system supplies calibration gas through the calibration line to the sample probe at the calibration flow rates that range between 10 and 15 standard liters per minute (slpm). Calibration gases are injected through the entire sample line so that the sample line pump is constantly drawing an adequate calibration sample to the CO analyzer.

The sample/calibration bundle is comprised of two Teflon lines. The sample lines are connected to each sample probe, through a particulate filter (at the probe end of the line). The sample is drawn from the probe by a positive displacement pump that discharges to a tee. One leg of the tee is connected to an atmospheric vent and the other leg of the tee is connected to a fine particulate filter just prior to entering a CO analyzer. The sample line pump is set to operate so that the velocity in the sample line is sufficient so that sample residence time in the sample line is always less than 20 seconds. The second line in the sample/calibration bundle is a Teflon line that is connected from the calibration system to the sample probe.

3.3.4 PM_{10} Monitoring System

PM_{10} levels in the full-transverse ventilated section of the CA/T roadway are monitored continuously in key locations in the exhaust plenums before the exhaust air is diverted up through the VB exhaust stacks to the outside atmosphere. There are no continuous PM_{10} CEM monitors located inside longitudinally ventilated exit ramps. At longitudinally ventilated exit ramp CS-SA, a CEM PM_{10} monitor is located adjacent to the exit portal itself. The CEM equipment used to measure and/or record PM_{10} levels at these locations is described below. It should be noted that PM_{10} CEM monitor at ramp CS-SA was relocated from its original location along the CS-SA roadway just outside the exit portal to the top of the ramps boat-wall section. This was because the original location of the monitor was to close to the exit portal. The new location is more representative of the ambient PM_{10} conditions as was the intention of the monitoring. The location change for the ramp CS-SA monitor was made starting May 1, 2006.

3.3.4.1 VBs and Longitudinally Ventilated Exit Ramp

The PM_{10} CEM monitoring system located at VBs 3, 5 and 7 and longitudinally ventilated exit Ramp CS-SA, consists of the following equipment:

- A continuous PM_{10} sampler with a detection range of 0 micrograms per cubic meter to 500 micrograms per cubic meter,
- System Controller/Data Logger.

PM_{10} CEM equipment located at VB 3 is continuously monitoring particulate emissions from vehicles traveling on north and southbound I-93 tunnel sections. PM_{10} equipment located at VB 5 and VB 7, continuously monitor PM_{10} emissions from vehicles traveling on east and westbound I-90 tunnel sections.

3.3.4.2 Monitoring Locations and Housing

The PM_{10} sensor units at VBs 3, 5 and 7 are housed in a NEMA certified 4x enclosure located in the exhaust plenums of each VB. The PM_{10} sensor unit located at longitudinally ventilated exit ramp CS-SA samples air outside of the exit portal of the ramp itself. The intent of this monitor was to measure ambient PM_{10} levels in the vicinity of the longitudinally ventilated exit ramp. This ramp was selected because of its close proximity to a residential community and because of the highest potential impacts predicted at the sensitive receptors in the wind-tunnel study.

3.3.5 Data Acquisition and Handling System

Data from the CO and PM_{10} CEM systems located at VBs 1, 3, 4, 5, 6 and 7 and longitudinal ventilated exit Ramps L-CS, CN-S, SA-CN, CS-SA, ST-SA/ST-CN, CS-P, DST-I93, DST-I-90 and F, is recorded using a System Controller/Data Logger (data logger) at each location. The data loggers constitute the Data Acquisition Handling System (DAHS) for each CEM location. The data loggers control the calibration routines for the CO analyzers and records of all CO and PM_{10} concentrations on a hourly/daily basis. A separate PC with compatible data logger software is used to download and store CO and PM_{10} concentrations from each CEM location.

3.4 CONTINUOUS EMISSIONS MONITORING SYSTEMS INITIAL CERTIFICATION

The CA/T's ventilation system is unique in many ways. As such, the certification process performed for monitoring the emissions from the ventilation system is also unique in its application to the Project's ventilation system. Equipment certification and operations are specifically tailored for use in the Project's emissions monitoring program and reflect the unique application for which the equipment is being used.

3.4.1 CO Monitoring System

3.4.1.1 CO Analyzer Multi-Point Calibration Test

The CO analyzers that are used to monitor CO concentration in the exhaust plenum and at the longitudinally ventilated exit ramps, were calibrated using the system dilution calibration device at zero (0) concentration and at four (4) calibration points over the range of the instrument. Calibration concentrations were: a high value 100-135 ppm, a mid-range 45–75 ppm, a low-range 20–30 ppm, and a low-low-range 5-10 ppm. Calibration gas was injected directly into each CO analyzer. The instruments were adjusted first at the zero level and then at the high value. After each instrument was adjusted at the high value, the zero level was injected again. If the zero level required re-adjustment, then the high level concentration was injected again. If necessary, several iterations between the zero and high level concentrations were performed to ensure that an analyzer was calibrated. The calibration specification for acceptability was ±1.0 ppm for zero and ±5% of the input concentration for the high level point. All remaining concentrations levels were injected without any further analyzer adjustments. The average Δ% for calibration points were not allowed to exceed ±5% where:

$$\Delta\% = \frac{(\text{Analyzer Response} - \text{Input Concentration})}{\text{Input Concentration}}\, x\, 100$$

Where :

Analyzer Response = Concentration recorded by an analyzer

Input Concentration = Input calibration gas concentration

3.4.1.2 Cycle Time and Linearity Test

For this test, all monitoring systems were operated in their normal sampling mode, including the time sharing mode for the equipment located at VB 7.

Low-level calibration gas with a value of 40 to 50 ppm were input through the entire monitoring system for 30 minutes, or until a stable response was achieved. At the end of the period, a high-level calibration gas with a value of 80 to 90 ppm was input through the entire monitoring system for 30 minutes or until a stable response occurred.

The amount of time it took for 95% of the step change to be achieved between a stable low level and high-level calibration gas response was determined. The cycle time test was successful was the response time achieved was less than 15 minutes.

The linearity of the monitoring system to the low and high scale calibration gases was also tested during the cycle time test. To pass the linearity test, the monitoring system response had to be within ±5% of the low and high-level calibration gas input values using the formula:

$$\text{Linearity } \Delta\% = \frac{(\text{System Response} - \text{Input Concentration})}{\text{Input Concentration}} \, x \, 100$$

Where:

System Response = Concentration recorded by the analyzer when the calibration gas is injected through the entire system

Input Concentration = Input calibration gas concentration

3.4.1.3 Seven-Day Calibration Drift Test

The calibration drift of each monitoring system was measured once a day (approximately 24 hours apart) for seven consecutive days using zero and span gases. No manual or automatic adjustments were made to any analyzer until after recording all responses.

To pass the seven-day drift test for the zero point, each analyzer's zero drift could not be greater than ±1% (1.5 ppm) of the analyzer full-scale range (150 ppm) per day. Drift for the span gas was calculated as follows:

$$\text{Calibration drift} = \frac{(\text{Analyzer Response} - \text{Input Concentration})}{\text{Input Concentration}} \, x \, 100$$

Where :

Analyzer Response = Concentration recorded by the analyzer

Input Concentration = Input span gas concentration

To pass the seven-day drift test for the span gas, each analyzer's span drift could not be greater than ±5% of the span value per day.

3.4.1.4 System Bias Test

After each CO analyzer was calibrated, a system bias check was performed. The high-level calibration concentration was injected through the entire emission monitoring system. The acceptable system bias was ±5% according to the equation:

$$\text{System Bias} = \frac{\text{System Response} - \text{Direct Analyzer Response}}{\text{Direct Analyzer Response}} \quad \times \quad 100$$

Where:

System Response = Concentration recorded by the analyzer when the calibration gas was injected through the entire system

Direct Analyzer Response = Concentration recorded by the analyzer when the calibration gas was injected directly into the analyzer

3.4.2 PM_{10} Monitoring System

Tests performed on each PM_{10} unit located at VBs 3, 5 and 7 and outside longitudinally ventilated exit Ramp CS-SA, consisted of calibration/certification of each particulate monitoring system, including the calibration of the main and auxiliary flow rate, the on-board temperature sensor, and the barometric pressure sensor by its referenced standard. In addition, verification of the Ko constant of each PM_{10} unit mass transducer taper element was conducted by using five pre-weighed filters.

In all cases, the manufacturer recommended procedures specified in the PM_{10} unit's operating manuals were applied for all certifications tests. Reference standards used were either primary standards or working standards traceable to National Institutes of Standards and Technology (NIST).

3.4.2.1 K Factors

% Error of Ko = 100 x (Average Ko – Actual Ko) /Designated Flow

The allowable Ko error ± 2.5%.

3.4.2.2 Flow

% Error of Flow = 100 x (Average Flow – Designated Ko)/Designated Flow

The allowable flow error is ± 7%.

3.4.2.3 Temperature and Barometric Pressure

Error = Display Value – Audit Value

The allowable temperature error is ± 2°C. The allowable barometric pressure error is ± 10 mm Hg.

3.4.3 Continuous Emissions Monitoring Certification Data Submittal

Results for certification tests performed on CO CEM equipment (i.e., multi-point calibration, cycle time/linearity, seven-day drift and system bias) and PM_{10} CEM equipment (i.e., K-factor, system flow and temperature/barometric pressure), are presented in Appendix D. "CEM Certification Test Data".

3.5 TRAFFIC MONITORING

The CA/T Project has an extensive array of video cameras to monitor traffic conditions through the entire project. The main function of this centralized system, which is operated by the OCC, is to monitor real time traffic conditions to assist the OCC operations in conducting safe tunnel operation. At the present time these cameras only provide real time images and have no storage capability.

Specifically, the Project has selected four locations where hourly traffic volumes will be recorded, as follows:

- I-93 southbound in the vicinity of Causeway Street
- I-93 northbound in the vicinity of South Station
- I-90 westbound in East Boston
- I-90 eastbound in the vicinity of Fort Point Channel

These locations represent the tunnel sections that account for the vast majority of the Project's traffic volumes, and as such, they will provide Mass DEP with a very good indication of the peak hourly and daily traffic volumes passing thru the CA/T tunnels.

4 CONTINUOUS EMISSIONS MONITORING PLAN

4.1 PROJECT-WIDE QUALITY ASSURANCE/QUALITY CONTROL PROGRAM

This section describes the overall quality assurance (QA) and quality control (QC) program for the continuous air emissions monitoring portion of the long-term Compliance Monitoring Program for the CA/T Project. CEM equipment currently in-place for CA/T's Operating Certification, along with specific information regarding the CEM QA/QC program, are described in Attachment 1, "CEM Air Emissions Monitoring Protocol" to this document.

The QA/QC program sets forth, among other things, the procedures to be followed and the criteria to be met, where applicable, for:

- operating, maintaining and calibrating the CEMS equipment and related components,
- determining the quality of the measured data, and
- developing emissions-related parameters or directly reporting the measurement results to the Mass DEP in order to demonstrate project compliance status with respect to the ambient concentration limits in 310 CMR 7.38(2)(a).

The QA/QC program has been developed through extensive technical consultation with the Mass DEP taking into consideration Federal Regulations 40 CFR Parts 58, 60 and 75. The procedures to be followed also take into account equipment manufacturer's recommendations as well as good engineering practice.

4.1.1 Quality Assurance/Quality Control – Definition and Function

QA, as it relates to the continuous air emissions monitoring program for the CA/T Project, represents those planned or systematic activities, independently performed, that are required to ensure that the measurements made and the data reported to regulatory authorities are representative, acceptably accurate, and supported by defendable documentation.

QC, as it is to be implemented for this monitoring program, represents the series of routine and periodic operational activities (based on regulatory requirements, good engineering practice, and the agreed-upon approach for this hybrid monitoring system) that are necessary for maintaining and improving data quality and the instruments and systems that produce that information.

QA checks also serve to ensure that the QC function is not only being implemented properly, but that it is adequate to the task, such that when (or even before) data accuracy or documentation becomes unacceptable, actions are taken to identify and resolve the issues or procedural steps affecting data quality until acceptable performance is once again achieved. Periodic review of implementation and documentation are typically referred to as "Systems Audits".

Corrective action encompasses both internal policies and regulatory requirements. This QA/QC program focuses primarily on the corrective actions required to return an out-of-control system or component back to a status of compliance; but, it also acknowledges the need for periodic review of the CEM Air Emissions Monitoring Protocol and related standard operating procedures (SOPs) based on accumulated operating experience and opportunities for improvement identified as a result of Systems Audits.

4.1.2 QA/QC Goals and Objectives

The goals of this QA/QC program are to collect measurement data of known and acceptable quality and quantity, and to generate and maintain the records required to demonstrate that the continued operation of the tunnel and exit ramp ventilation systems results in compliance with the air quality criteria set forth in 310 CMR 7.38(2)(a).

In order to do so, MTA is committed to installing, certifying, operating, maintaining and calibrating continuous emissions monitoring and related systems in accordance with applicable Commonwealth of Massachusetts regulations at 310 CMR 7.38(8) and 7.38(9), agreed-upon requirements adapted from Federal regulations conditions in the CA/T Project's Operating Certification, the QA/QC program laid out in Attachment 1, and good engineering practice.

4.1.3 Organization and Responsibilities

This section summarizes key personnel, responsibilities and organizational structure for the continuous air emissions monitoring portion of the long-term Compliance Monitoring Program for the CA/T Project which is established pursuant to 310 CMR 7.38 and implemented in accordance with the requirements of the CA/T's Operating Certification.

4.1.3.1 Director of Environmental Engineering

The director of Environmental Engineering is responsible for the overall implementation of the CEM Program described within.

4.1.3.2 Senior Environmental Engineer

The Senior Environmental Engineer is responsible for technical oversight of the continuous air emissions monitoring program and its execution. The Senior Environmental Engineer interfaces with the Director of Environmental Engineering in carrying out the planning and administrative responsibilities of that position, and with QA Management to ensure that all program activities affecting data quality are performed and documented in accordance with the CEM Air Emissions Monitoring Protocol and the applicable SOPs. The Senior Environmental Engineer also serves as technical liaison between the MTA and representatives of the Mass DEP and other regulatory agencies in regards to the monitoring program and the reported results.

Regarding implementation of the monitoring program, the duties of the Senior Environmental Engineer encompass:

- procurement of equipment, related components and materials;
- training and supervision of air quality staff, participating in the operation, maintenance and calibration of the CEMS equipment and related components, and interpreting CEMS output by the DAHS;

- ensuring that routine and periodic QC inspections, instrument response checks, calibrations and adjustments are performed and documented as required;
- verifying that measurement and QC check data are recorded and reviewed on a regular basis, and that measurement data are reduced and validated properly;
- review, approval and timely submittal of monthly (first year of full operations only) and quarterly (thereafter) reports of CEMS data and QC check results;
- supporting periodic independent and third-party QA Performance and Systems Audits in coordination with QA Management, regulatory agencies (as applicable), and any subcontractor(s) that may conduct such work;
- review and timely submittal of semi-annual QA Performance Audit and annual Systems Audit reports; and
- resolution of any issues resulting from routine operations, maintenance, QC checks or QA audits, evaluating the need for Monitoring Plan revision in coordination with QA Management and, when required, revising the CAEMP or the accompanying SOPs;
- daily review of CO and PM_{10} measurement data and periodic review of calculated NO_x concentrations for each monitoring location in relation to the corresponding Operating Certification limits, traffic volumes and tunnel operating conditions;
- regular review of QC check results (i.e., daily CO analyzer response checks) versus applicable acceptance criteria and action limits;
- routine processing and summarization of measured hourly average CO concentrations, calculated hourly average NO_x concentrations, daily (24-hour) average PM_{10} measurements, and daily and periodic QC check results;
- validation of CO and PM_{10} measurement data based on operating status of analyzers and related instrumentation, and the results of daily QC response checks (CO only), other periodic QC checks (e.g., multi-point calibrations, flow rate verifications), and periodic QA Performance Audits;
- preparation of monthly (first year of full operations only) or quarterly (thereafter) reports of CEMS data, QC check results, and excess emissions (if any) in accordance with 310 CMR 7.38(9)(a)(2);
- supporting preparation of semi-annual QA Performance Audit reports and annual QA Systems Audit reports;
- retaining all measurement data, results of periodic QC checks and QA Performance and Systems Audits, and other related documentation (e.g., records of routine and periodic inspections and preventive maintenance) for a period of at least five years in accordance with 310 CMR 7.38(9)(a)(1);
- the conduct of periodic independent QA Performance Audits - for example, semi-annual multi-point calibration response and bias checks of the CO analyzers, and semi-annual verification of PM_{10} mass transducer calibration and flow audit response;
- the performance of annual independent QA Systems Audits of monitoring program implementation and related documentation;
- the scheduling and conduct of any third-party (i.e., regulatory agency) QA Performance or Systems Audits; and
- the preparation and review of the corresponding QA Performance and Systems Audit reports.

If necessary, Data Management responsibilities may be integrated with the responsibilities of the Senior Environmental Engineer and/or his designee (e.g., Environmental Engineer, Environmental Technicians).

4.1.3.3 Environmental Engineer and Environmental Technicians

The Environmental Engineer with the assistance of the Environmental Technicians, working with direction from the Senior Environmental Engineer, is responsible for routine operation, maintenance and calibration of the CEMS and all related components. In this regard, the duties of the Environmental Engineer and Environmental Technicians include:

- inspection of the CEMS equipment and shelters on a regular basis (e.g., analyzer and equipment settings and readouts, alarms appearing on instrumentation or generated by the DAHS, calibration gas bottle pressures and inventory, general housekeeping);
- completing periodic (e.g., weekly, monthly, semi-annual, annual) preventive maintenance items on the CEMS and related equipment;
- maintaining an adequate inventory of spare parts and consumable items such that instrument downtime is minimized to the extent practicable;
- conducting and/or evaluating periodic QC checks – for example, daily, quarterly, annual checks of CO analyzer response and calibration gas dilution system flow meter accuracy, and quarterly, semi-annual and annual verifications and/or calibrations of PM_{10} monitor flow rate and related flow or measurement system components; and
- supporting independent semi-annual QA Performance Audits and annual QA Systems Audits, or other third-party (e.g., Mass DEP) audits.

As indicated at the end of the preceding subsection, the Environmental Engineer and/or Environmental Technicians may undertake some of the Data Management responsibilities if so assigned by the Senior Environmental Engineer.

4.1.4 Document Distribution and Control

As a matter of practicality, copies of the Continuous Air Emissions Monitoring Plan will not be placed at each continuous emissions monitoring location simply because of the number of sites in the monitoring network. Rather, distribution of the CEM Air Emissions Monitoring Protocol will be via Controlled Copy for those individuals and organizations with a need-to-know function that directly affects the successful implementation, management and/or oversight of the continuous air emissions monitoring program. Each Controlled Copy shall be sequentially numbered.

At a minimum, recipients of Controlled Copies of the CEM Air Emissions Monitoring Protocol (Attachment 1) will include:

- Director of Environmental Engineering
- Senior Environmental Engineer
- Environmental Engineer
- Environmental Technicians

Uncontrolled copies will also be distributed to individuals or organizations on an as-needed basis for informational purposes where casual familiarity with the monitoring program may be beneficial but is not essential. The Senior Environmental Engineer in coordination with the Director of Environmental Engineering shall approve such recipients.

Distribution of Controlled Copies of the CEM Air Emissions Monitoring Protocol, and revisions to it, will be documented on form MTA-ENV-FORM01. Recipients shall sign the distribution form, return the original to the Senior Environmental Engineer or designee, and retain a copy of the signed form. The signed original shall be retained by the Director of Environmental Engineering.

Distribution of Uncontrolled Copies of the CEM Air Emissions Monitoring Protocol shall be by formal transmittal letter or e-mail, as appropriate. Documentation of all such transmittals shall also be retained by the Director of Environmental Engineering.

The CEM Air Emissions Monitoring Protocol may be updated periodically as operational experience with the CEM system is gained, as the effectiveness of the SOPs and the staff's execution of them is demonstrated (as evidenced by the quality of the data and related documentation produced), and as evaluated through the results of periodic QA Performance and Systems Audits.

At a minimum, the CEM Air Emissions Monitoring Protocol will be reviewed annually by the Senior Environmental Engineer in coordination with QA Management; more frequently, if required (e.g., due to failure of multi-point calibrations or an intervening semi-annual QA Performance Audit during two consecutive calendar quarters, frequently occurring out-of-control periods).

Revisions to any requirement of the CEM Air Emissions Monitoring Protocol (e.g., the frequency of equipment and data inspections, instrument response checks, calibration checks and adjustments) or to SOPs shall be agreed upon by the Senior Environmental Engineer and QA Management before incorporation. All changes to the CEM Air Emissions Monitoring Protocol shall be clearly marked on each affected page with the Revision Number, Date and Page Number updated accordingly. Controlled Copies of the affected sections (or subsections), or an individual SOP shall be re-issued by the Senior Environmental Engineer with distribution and receipt to be documented as described above. The Senior Environmental Engineer or designee shall keep a chronological log that summarizes all such revisions.

The Senior Environmental Engineer will identify all parties directly affected by such revisions and will coordinate the necessary training to implement those changes in a timely manner. The appropriate mode of training shall be at the discretion of the Senior Environmental Engineer.

4.2 TRAINING

Training represents an essential element of a successful QA/QC program by identifying the objectives to be accomplished and by providing the basic knowledge required to successfully complete a procedure or task. In this QA/QC program, training takes the form of:

- general training,
- specialized vendor training,
- monitoring plan review, and
- periodic refresher and specialized training

Training and subsequent implementation can also provide a more thorough understanding (over time) of a given task or procedure that enables the individual involved to make more timely and effective decisions while executing the process or improving on the process itself. Therefore, training is the cornerstone of the framework within which activities are performed in a consistent manner regardless of who completes them.

4.2.1 General Training

General training is not intended as much to deliver detailed and specific knowledge, as it is to provide an overall understanding of the goals and objectives of the CA/T Project's continuous air emissions monitoring program within the framework of the CEM Air Emissions Monitoring Protocol. General training will be provided to all individuals directly involved with the CEM program.

4.2.2 Specialized Vendor Training

Specialized training in the installation, operation, maintenance and calibration of the various monitoring systems and related components will be provided to the Senior Environmental Engineer, and to the Environmental Engineer, Environmental Technicians, or other support staff, as appropriate, by the respective system vendors either at the time of or soon after initial installation of the equipment. Trainees will also be familiarized with the corresponding System Manuals.

4.2.3 Monitoring Plan Review

All personnel involved in the routine operation, maintenance and calibration of the CEMS, related components, and related systems (e.g., the DAHS), or in the review, processing, validation and reporting of the data produced by those pollutant measurement systems will be required to review:

- the appropriate sections and/or Parts of this document (including the applicable requirements adapted from the regulations under 40 CFR Parts 58, 60 and 75), and
- the CEM Air Emissions Monitoring Protocol, SOPs and corresponding System Manuals.

4.2.4 Periodic Refresher and Specialized Training

Refresher training will occur periodically (e.g., following review of the effectiveness of the CEM Air Emissions Monitoring Protocol and accompanying SOPs). Training sessions will be held with affected personnel when specific procedures are revised as a result of this review or when necessitated as part of a corrective action process (e.g., following an independent Systems Audit).

When changes in personnel or assigned responsibilities take place, the degree of specialized training will be tailored to the level of previous experience with the CA/T Project's continuous air emissions monitoring program, specific systems, and tasks to be performed. Specialized training in the operation, maintenance and calibration of the various monitoring systems and components may be conducted by the vendor or by previously trained in-house staff.

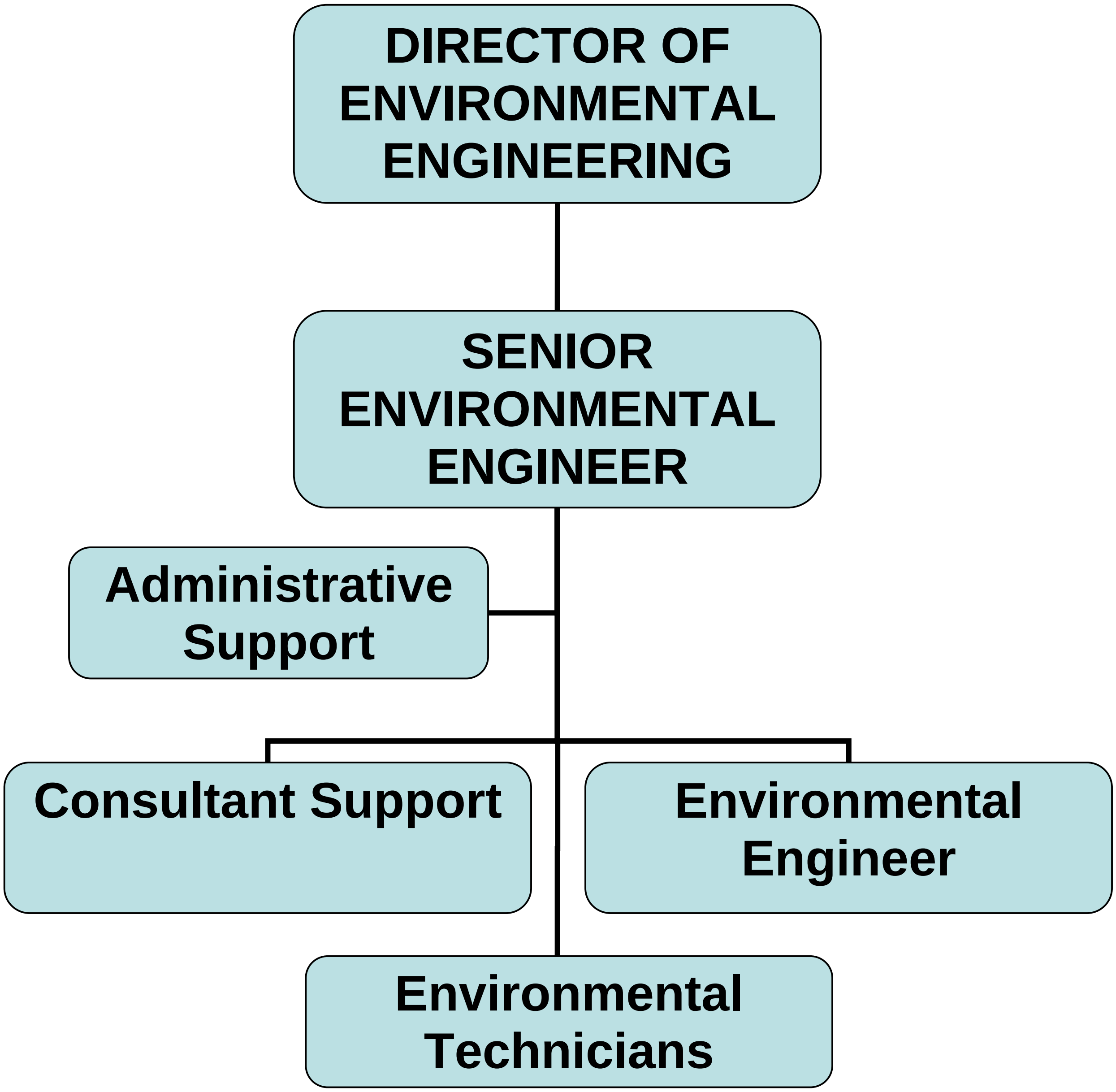
Finally, when system components change (e.g., the replacement of a pollutant monitor with an instrument that bases its measurements on a different analytical method – as opposed to the repair or replacement of a failed part) or software upgrades to the DAHS are made, specialized vendor training will take place for those personnel whose responsibilities or procedures are affected.

TABLE 4-48: KEY PERSONNEL AND RESPONSIBILITIES

Title	Responsibilities
Director of Environmental Engineering	• Overall implementation of the program
Senior Environmental Engineer	• Technical oversight of CEM program • Procure CEMS-related equipment/materials • Determine training needs of AQ staff and, as required, other program participants • Supervise Environmental Engineer and Environmental Technicians and support those responsibilities as needed • CEMS data and QC check report review/submittal • QA Performance Audit report review/submittal • QA Systems Audit report review/submittal • Revise CAEMP and SOPs (as necessary) and coordinate/conduct associated refresher training • Daily[1] data review • Data processing and validation • Prepare CEMS data and QC check reports • Support preparation of QA Performance and Systems Audit reports • Coordinate conduct of semi-annual/annual QA Performance Audits and annual QA Systems Audits • Coordinate preparation/review of Performance and Systems Audits reports
Environmental Engineer and/or Environmental Technicians	• CEMS operation, maintenance and calibration • Regular CEMS inspections[2] • Conduct quarterly, semi-annual and annual QC checks • Support independent QA Performance/Systems Audits

Notes:
1 – Data to be reviewed on a daily basis, nominally, during regular work week (Mon-Fri).
2 -- Each site to be visited 2 times, nominally, per regular work week (Mon-Fri).

FIGURE 4-1: ORGANIZATIONAL STRUCTURE FOR THE MTA-CA/T PROJECT CONTINUOUS AIR EMISSIONS MONITORING PROGRAM



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Part III - Record Keeping and Reporting

5 DATA RECORDING AND REPORTING

5.1 MASS DEP 310 CMR 7.38(9) REGULATORY REQUIREMENTS

Massachusetts DEP Regulation 310 CMR 7.38(9) states the following requirements for record keeping and reporting:

"(a) Any person who constructs and operates a tunnel ventilation system on or after January 1, 1991 shall comply with the following record keeping and reporting requirements:

1. *All records and data from the continuous emissions monitors, recorders and traffic monitors shall be maintained for a period of five years. The most recent two years of data shall be readily available for Department inspection.*
2. *Emissions Reporting. For the first year of operations monthly reports shall be filed with the Department no later than 30 days following the end of the preceding calendar month. Said monthly reports shall contain a summary of continuous monitoring data showing any excursions from allowable emission limitations contained in the Department's acceptance of the certification. In the event any of the reported data shows an excursion of the emission limitations set forth in the acceptance of certification, a written explanation of any excursion shall be included. Evidence of each calibration event on the monitoring devices shall be included in such monthly reports.*
3. *Traffic Reporting. For the first year of operation monthly reports shall be filed with the Department no later than 30 days following the end of the preceding calendar month. Said monthly reports shall contain a summary of average daily and peak hour counts of vehicle miles traveled as well as average daily and peak hour vehicle speeds and vehicle hours traveled as identified through the traffic monitoring network established pursuant to 310 CMR 7.38(8).*
4. *Tunnel Ventilation System Maintenance. For the first year of operations monthly reports shall be filed with the Department no later than 30 days following the end of the preceding calendar month. Said monthly reports shall contain a summary of routine maintenance checks performed, repairs of ventilation equipment, amount of time during which ventilation equipment was not operating in accordance with standard operating procedures and measures taken to remedy this situation.*

(b) After the first year of operation, the reports required by 310 CMR 7.38(9) shall be submitted to the Department on a quarterly basis, with the first such quarterly report being due no later than 30 days after the end of the quarter and every three months thereafter."

5.2 CONTINUOUS EMISSIONS MONITORING MEASUREMENT DATA PROCESSING

As described in Section 3.3.3 and 3.3.4, all CO and PM_{10} CEM data are recorded using data loggers located at each CEM location. Data from each data logger is downloaded via a modem to a central PC. All CO and PM_{10} data are reviewed edited as necessary and daily data summaries for each month are generated. Using the edited daily summaries, NO_2 emission concentrations are developed using the CO to NO_2 conversion ratio described in Section 2.4.5.

5.3 TRAFFIC DATA PROCESSING

The OCC will record hourly volumes at the following locations:
- I-93 southbound in the vicinity of Causeway Street
- I-93 northbound in the vicinity of South Station
- I-90 westbound in East Boston
- I-90 eastbound in the vicinity of Fort Point Channel

Peak hourly and average daily traffic volumes at each of the four locations will be reported to Mass DEP on a monthly basis. The data will also provide the monthly average daily volumes for each location. Historically, motor vehicle emissions were very dependent on traffic speeds, but recent studies had found no clear correlation between traffic speeds and measured in-tunnel emission levels. Based on these recent findings, the Project found no compelling reason to record traffic speeds as part of the continuous traffic monitoring program. As such only volumes will be recorded and submitted.

5.4 TUNNEL VENTILATION SYSTEM MAINTENANCE RECORDS

Tunnel ventilation records for both routine and non-routine maintenance activities are logged and tracked through the Project's Maintenance Management Information System (MMIS). As described in section 1.2.1 each ventilation zone has multiple exhaust fans that serve that zone. Each zone can operate with one functioning fan. If however, multiple exhaust fans within a ventilation zone are to undergo repair that results in only one operating exhaust fan, MTA will notify Mass DEP via monthly report as to the extent of the maintenance that will be performed and the duration of the repairs. The reports, if any, will be provided on a monthly basis for the first year of Operating Certification and on a quarterly basis thereafter.

5.5 CONTINUOUS EMISSIONS MONITORING DATA SUMMARY REPORTS

For the period October 2005 through April 2006, initial hourly CO, NO_x and PM_{10} CEM data for each month is presented in Appendix E, "Initial CEM Data in Support of Operating Certification". Starting in June 2006, these data will be compiled and submitted to the Mass DEP on a monthly basis for the period May 2006 through October 2007 and on a quarterly basis thereafter.

A summary of the CO, NO_x and PM_{10} average and peak levels for each VB (Tables 5-1 to 5-6) and longitudinally ventilated section collected between October 2005 and April 2006 are provided in Tables 5-7 to 5-14. The applicable emission limits for CO, NO_x and PM_{10} are also set forth in these tables.

The collected data indicates that measured CO concentrations range from 1 to 6 ppm during off-peak and as high as 26 ppm during peak periods. The measured NO_x levels range from 0.3 to 0.8 ppm in the off-peak hours and from 1.3 to 3.2 in the peak hours. The measured average daily PM_{10} concentrations are in between 29 and 153 $\mu g/m^3$ and the measured maximum daily concentrations range from 49 to 365 $\mu g/m^3$. Some of the measured peak PM_{10} levels have been associated with the nighttime construction activities related to the tunnel leaks. The levels are expected to get lower once the repair and construction process is finished.

TABLE 5-1: SUMMARY OF CO, NO_X AND PM_{10} AVERAGE AND PEAK LEVELS: VENTILATION BUILDING 1

Monitor Location: VB1 Exhuast Ducts 1 & 2 (Ramp L/HOV for I-90 EB)

Pollutant	Time Period	Emission Limits	Parameter	Unit	10/05	11/05	12/05	01/06	02/06	03/06	04/06
CO	1 Hour	70 ppm	Maximum	ppm	9.8	6	3.6	3.4	8.7	3.9	8.7
			Average	ppm	1.3	1	1.1	0.9	1.4	1.2	1.2
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
	8 Hour	70 ppm	Maximum	ppm	4	2.9	3	2.1	6.7	2.6	4.4
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
NO_x	1 Hour	8.88 ppm	Maximum	ppm	1.4	0.9	0.6	0.6	1.3	0.7	1.3
			Average	ppm	0.4	0.3	0.3	0.3	0.4	0.4	0.4
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0

Monitor Location: VB1 Exhuast Ducts 8 & 9 (Ramp L/HOV for I-90 EB)

Pollutant	Time Period	Emission Limits	Parameter	Unit	10/05	11/05	12/05	01/06	02/06	03/06	04/06
CO	1 Hour	70 ppm	Maximum	ppm	8.8	6.3	6.1	4.7	9.1	4.1	5.8
			Average	ppm	2.2	1.7	1.7	1.7	1.7	1.2	1.3
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
	8 Hour	70 ppm	Maximum	ppm	7.4	4.2	5.5	2.9	8.1	2.1	3.7
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
NO_x	1 Hour	8.88 ppm	Maximum	ppm	1.3	1	1	0.8	1.3	0.7	0.9
			Average	ppm	0.5	0.4	0.4	0.4	0.4	0.3	0.4
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0

Monitor Location: VB1 Exhuast Ducts 3 & 4 (I-90 EB)

Pollutant	Time Period	Emission Limits	Parameter	Unit	10/05	11/05	12/05	01/06	02/06	03/06	04/06
CO	1 Hour	70 ppm	Maximum	ppm	2.9	3	3.8	3.9	4.7	2.3	4.2
			Average	ppm	0.9	0.9	0.8	0.9	0.7	0.6	0.8
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
	8 Hour	70 ppm	Maximum	ppm	2.2	2.7	3.3	3.4	4.5	1.7	2.2
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
NO_x	1 Hour	8.88 ppm	Maximum	ppm	0.6	0.6	0.7	0.7	0.8	0.5	0.7
			Average	ppm	0.3	0.3	0.3	0.3	0.3	0.3	0.3
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0

Note: EL = Emission Limit

TABLE 5-1: SUMMARY OF CO, NO_X AND PM_{10} AVERAGE AND PEAK LEVELS: VENTILATION BUILDING 1 (CONTINUED)

Monitor Location: *VB1 Exhaust Ducts 7 (I-90 WB)*

Pollutant	Time Period	Emission Limits	Parameter	Unit	10/05	11/05	12/05	01/06	02/06	03/06	04/06
CO	1 Hour	70 ppm	Maximum	ppm	2.4	6.5	3.8	3.9	9.1	7.6	3.4
			Average	ppm	0.8	0.9	0.7	0.8	0.7	0.5	0.9
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
	8 Hour	70 ppm	Maximum	ppm	2	2.4	3.1	3.4	3.4	2.3	3
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
NO_x	1 Hour	8.88 ppm	Maximum	ppm	0.5	1	0.7	0.7	1.3	1.1	0.6
			Average	ppm	0.3	0.3	0.3	0.3	0.3	0.3	0.3
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0

Monitor Location: *VB1 Exhaust Ducts 5 & 6 (I-90 WB)*

Pollutant	Time Period	Emission Limits	Parameter	Unit	10/05	11/05	12/05	01/06	02/06	03/06	04/06
CO	1 Hour	70 ppm	Maximum	ppm	3.2	7.3	2.7	3.7	9	8.4	2.6
			Average	ppm	1.3	1.3	1.1	1.2	1	0.9	1
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
	8 Hour	70 ppm	Maximum	ppm	2.6	2.9	2.3	2.6	3.1	3	1.8
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
NO_x	1 Hour	8.88 ppm	Maximum	ppm	0.6	1.1	0.5	0.7	1.3	1.2	0.5
			Average	ppm	0.4	0.4	0.3	0.3	0.3	0.3	0.3
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0

Monitor Location: *VB1 Exhaust Ducts 10 & 11 (Ramp D I-90 WB to I-93 NB)*

Pollutant	Time Period	Emission Limits	Parameter	Unit	10/05	11/05	12/05	01/06	02/06	03/06	04/06
CO	1 Hour	70 ppm	Maximum	ppm	9.5	7.9	5.5	5.3	8.8	4.2	3.4
			Average	ppm	1.6	1.6	1.2	1.3	1.2	0.8	1.3
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
	8 Hour	70 ppm	Maximum	ppm	3.5	3.7	2.6	2.8	3.1	2.2	2.8
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
NO_x	1 Hour	8.88 ppm	Maximum	ppm	1.4	1.2	0.9	0.9	1.3	0.7	0.6
			Average	ppm	0.4	0.4	0.4	0.4	0.3	0.3	0.4
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0

Note: EL = Emission Limit

TABLE 5-2: SUMMARY OF CO, NO_X AND PM_{10} AVERAGE AND PEAK LEVELS: VENTILATION BUILDING 3

Monitor Location: VB3 NB-1

Pollutant	Time Period	Emission Limits	Parameter	Unit	10/05	11/05	12/05	01/06	02/06	03/06	04/06
CO	1 Hour	70 ppm	Maximum	ppm	5	17.4	8.8	6.2	5.7	6.1	4.4
			Average	ppm	1.8	1.9	1.4	1.6	2.1	1.3	1.4
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
	8 Hour	70 ppm	Maximum	ppm	3.4	7.9	4.6	2.9	4	4.5	3.2
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
NO_x	1 Hour	8.88 ppm	Maximum	ppm	0.8	2.4	1.3	1	0.9	1	0.7
			Average	ppm	0.4	0.4	0.4	0.4	0.5	0.4	0.4
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
PM_{10}	24 Hour	500 mg/m3	Maximum	$\mu g/m^3$	247.5	144.4	235.3	197.6	174.6	141.7	174.7
			Average	$\mu g/m^3$	90.8	85.4	123.5	110.1	88.3	85.2	79.6
			Days exceed EL		0	0	0	0	0	0	0
			Days exceed 80% EL		0	0	0	0	0	0	0

Monitor Location: VB3 NB-2

Pollutant	Time Period	Emission Limits	Parameter	Unit	10/05	11/05	12/05	01/06	02/06	03/06	04/06
CO	1 Hour	70 ppm	Maximum	ppm	4.6	21.5	6.7	7.1	13.6	10	6.4
			Average	ppm	1.7	1.9	1	1.4	1.3	1.4	1.4
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
	8 Hour	70 ppm	Maximum	ppm	3.1	10.1	3.1	3.1	4.2	4.7	2.9
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
NO_x	1 Hour	8.88 ppm	Maximum	ppm	0.8	2.9	1	1.1	1.9	1.4	1
			Average	ppm	0.4	0.4	0.3	0.4	0.4	0.4	0.4
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0

Note: EL = Emission Limit

TABLE 5-2: SUMMARY OF CO, NO_X AND PM_{10} AVERAGE AND PEAK LEVELS: VENTILATION BUILDING 3 (CONTINUED)

Monitor Location:	VB3 SB-1										
Pollutant	*Time Period*	*Emission Limits*	*Parameter*	*Unit*	*10/05*	*11/05*	*12/05*	*01/06*	*02/06*	*03/06*	*04/06*
CO	**1 Hour**	**70 ppm**	**Maximum**	**ppm**	14.6	14.3	16.6	9.3	14.1	14.1	24.2
			Average	**ppm**	1.9	4	2.8	3.3	3.1	3.5	3.6
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
	8 Hour	**70 ppm**	**Maximum**	**ppm**	6.5	7.6	7.6	6.8	6.7	7.5	11
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
NO_x	**1 Hour**	**8.88 ppm**	**Maximum**	**ppm**	2	2	2.3	1.3	1.9	1.9	3.2
			Average	**ppm**	0.6	0.7	0.6	0.6	0.6	0.6	0.6
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
PM_{10}	**24 Hour**	**500 mg/m3**	**Maximum**	**$\mu g/m^3$**	137.8	157.6	262.9	214.6	211.9	183.1	150.1
			Average	**$\mu g/m^3$**	71	95	153.7	121	108.4	110.7	89.3
			Days exceed EL		0	0	0	0	0	0	0
			Days exceed 80% EL		0	0	0	0	0	0	0

Note: EL = Emission Limit

TABLE 5-3: SUMMARY OF CO, NO_X AND PM_{10} AVERAGE AND PEAK LEVELS: VENTILATION BUILDING 4

Monitor Location: VB4 NB3

Pollutant	Time Period	Emission Limits	Parameter	Unit	10/05	11/05	12/05	01/06	02/06	03/06	04/06
CO	1 Hour	70 ppm	Maximum	ppm	10.9	9.1	6.6	8.3	8.7	10.3	8.8
			Average	ppm	3.5	3.2	2.9	2.5	3.1	3.5	3.4
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
	8 Hour	70 ppm	Maximum	ppm	6.2	6	4.5	5.8	5.5	7	5.5
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
NO_x	1 Hour	8.88 ppm	Maximum	ppm	1.5	1.3	1	1.2	1.3	1.5	1.3
			Average	ppm	0.6	0.6	0.6	0.6	0.6	0.6	0.6
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0

Monitor Location: VB4 NB4

Pollutant	Time Period	Emission Limits	Parameter	Unit	10/05	11/05	12/05	01/06	02/06	03/06	04/06
CO	1 Hour	70 ppm	Maximum	ppm	12.1	10	7	8.9	9.7	11	8.4
			Average	ppm	2.9	2.4	2.3	2	2.4	2.1	2.6
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
	8 Hour	70 ppm	Maximum	ppm	6.6	5.6	5.1	6	5.3	6.9	5.3
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
NO_x	1 Hour	8.88 ppm	Maximum	ppm	1.7	1.4	1.1	1.3	1.4	1.6	1.2
			Average	ppm	0.6	0.5	0.5	0.5	0.5	0.5	0.5
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0

Note: EL = Emission Limit

TABLE 5-3: SUMMARY OF CO, NO_X AND PM_{10} AVERAGE AND PEAK LEVELS: VENTILATION BUILDING 4 (CONTINUED)

Monitor Location: VB4 SB2

Pollutant	Time Period	Emission Limits	Parameter	Unit	10/05	11/05	12/05	01/06	02/06	03/06	04/06
CO	1 Hour	70 ppm	Maximum	ppm	9.6	13.7	9.7	3.6	6.7	8.1	5.5
			Average	ppm	1.7	1.9	1.4	1	1.6	1.8	1.1
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
	8 Hour	70 ppm	Maximum	ppm	8.1	9.7	4.4	2.5	3.4	4.5	3.6
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
NO_x	1 Hour	8.88 ppm	Maximum	ppm	1.4	1.9	1.4	0.6	1	1.2	0.9
			Average	ppm	0.4	0.5	0.4	0.3	0.4	0.4	0.4
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0

Monitor Location: VB4 SB3

Pollutant	Time Period	Emission Limits	Parameter	Unit	10/05	11/05	12/05	01/06	02/06	03/06	04/06
CO	1 Hour	70 ppm	Maximum	ppm	6.5	6.4	7.7	5.3	5.5	5.2	9.2
			Average	ppm	1.3	1.1	1.7	1.5	1.9	1.8	1.8
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
	8 Hour	70 ppm	Maximum	ppm	5.3	3.9	4.2	4.2	3.5	4.2	7.6
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
NO_x	1 Hour	8.88 ppm	Maximum	ppm	1	1	1.2	0.9	0.9	0.8	1.3
			Average	ppm	0.4	0.4	0.4	0.4	0.4	0.4	0.5
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0

Note: EL = Emission Limit

TABLE 5-4: SUMMARY OF CO, NO_X AND PM_{10} AVERAGE AND PEAK LEVELS: VENTILATION BUILDING 5

Monitor Location: VB5 EB2

Pollutant	Time Period	Emission Limits	Parameter	Unit	10/05	11/05	12/05	01/06	02/06	03/06	04/06
CO	1 Hour	70 ppm	Maximum	ppm	7.4	4.2	4.5	9.6	4.3	8.8	5.1
			Average	ppm	1.6	1.6	1.4	1.6	1.1	1.4	1.3
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
	8 Hour	70 ppm	Maximum	ppm	4.4	3.3	2.8	7.3	3.1	7.9	3.5
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
NO_x	1 Hour	8.88 ppm	Maximum	ppm	1.1	0.7	0.8	1.4	0.7	1.3	0.8
			Average	ppm	0.4	0.4	0.4	0.4	0.3	0.4	0.4
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0

Monitor Location: VB5 EB3

Pollutant	Time Period	Emission Limits	Parameter	Unit	10/05	11/05	12/05	01/06	02/06	03/06	04/06
CO	1 Hour	70 ppm	Maximum	ppm	4.2	3.3	3.2	3.5	3.4	6.2	3.9
			Average	ppm	1.4	1.4	1.3	1.2	1	0.6	1.4
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
	8 Hour	70 ppm	Maximum	ppm	2.9	2.6	2.7	2.4	2.5	2.9	3.8
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
NO_x	1 Hour	8.88 ppm	Maximum	ppm	0.7	0.6	0.6	0.6	0.6	1	0.7
			Average	ppm	0.4	0.4	0.4	0.3	0.3	0.3	0.4
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0

Note: EL = Emission Limit

TABLE 5-4: SUMMARY OF CO, NO_X AND PM_{10} AVERAGE AND PEAK LEVELS: VENTILATION BUILDING 5 (CONTINUED)

Monitor Location: VB5 WB2

Pollutant	*Time Period*	*Emission Limits*	*Parameter*	*Unit*	*10/05*	*11/05*	*12/05*	*01/06*	*02/06*	*03/06*	*04/06*
CO	**1 Hour**	**70 ppm**	**Maximum**	**ppm**	3	3.5	2	9.2	3.1	3.2	2.5
			Average	**ppm**	1.1	0.7	0.6	1.4	0.9	1	0.7
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
	8 Hour	**70 ppm**	**Maximum**	**ppm**	2.7	2.8	1.6	9.1	2.3	2.6	2
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
NO_x	**1 Hour**	**8.88 ppm**	**Maximum**	**ppm**	0.6	0.6	0.4	1.3	0.6	0.6	0.5
			Average	**ppm**	0.3	0.3	0.3	0.4	0.3	0.4	0.3
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
PM_{10}	**24 Hour**	**500 mg/m3**	**Maximum**	**$\mu g/m^3$**	48.6	54.6	156.2	130.5	89.4	72.2	83.6
			Average	**$\mu g/m^3$**	28.7	33.7	56.1	47.5	55.7	41.3	32.7
			Days exceed EL		0	0	0	0	0	0	0
			Days exceed 80% EL		0	0	0	0	0	0	0

Monitor Location: VB5 WB3

Pollutant	*Time Period*	*Emission Limits*	*Parameter*	*Unit*	*10/05*	*11/05*	*12/05*	*01/06*	*02/06*	*03/06*	*04/06*
CO	**1 Hour**	**70 ppm**	**Maximum**	**ppm**	2.7	3.2	2.4	4.6	8	3.3	2.3
			Average	**ppm**	1.1	1.1	0.9	0.8	0.9	0.8	0.8
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
	8 Hour	**70 ppm**	**Maximum**	**ppm**	2.3	2.3	2.2	3.9	3.4	2.1	1.7
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
NO_x	**1 Hour**	**8.88 ppm**	**Maximum**	**ppm**	0.5	0.6	0.5	0.8	1.2	0.6	0.5
			Average	**ppm**	0.3	0.3	0.3	0.3	0.3	0.3	0.3
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0

Note: EL = Emission Limit

TABLE 5-5: SUMMARY OF CO, NO_X AND PM_{10} AVERAGE AND PEAK LEVELS: VENTILATION BUILDING 6

Monitor Location: VB6EB

Pollutant	Time Period	Emission Limits	Parameter	Unit	10/05	11/05	12/05	01/06	02/06	03/06	04/06
CO	1 Hour	70 ppm	Maximum	ppm	5.1	3.1	3.5	4.4	4.2	4.8	4.2
			Average	ppm	0.6	0.3	0.7	1.7	1.6	1.6	1.8
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
	8 Hour	70 ppm	Maximum	ppm	3.7	2.2	2.3	2.9	3.4	3.1	2.9
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
NO_x	1 Hour	8.88 ppm	Maximum	ppm	0.8	0.6	0.6	0.7	0.7	0.8	0.7
			Average	ppm	0.5	0.4	0.3	0.4	0.4	0.4	0.4
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0

Monitor Location: VB6WB

Pollutant	Time Period	Emission Limits	Parameter	Unit	10/05	11/05	12/05	01/06	02/06	03/06	04/06
CO	1 Hour	70 ppm	Maximum	ppm	4.3	4.9	5.8	7.7	12	9.3	7.3
			Average	ppm	0.2	0.6	2	2.7	3.2	3.4	2.9
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
	8 Hour	70 ppm	Maximum	ppm	3.3	4.2	4.6	4.2	5.9	5.2	5.4
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
NO_x	1 Hour	8.88 ppm	Maximum	ppm	0.7	0.8	0.9	1.2	1.7	1.3	1.1
			Average	ppm	0.5	0.5	0.6	0.5	0.6	0.6	0.6
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0

Note: EL = Emission Limit

TABLE 5-6: SUMMARY OF CO, NO_X AND PM_{10} AVERAGE AND PEAK LEVELS: VENTILATION BUILDING 7

Monitor Location: *VB7 TA/D*

Pollutant	*Time Period*	*Emission Limits*	*Parameter*	*Unit*	*10/05*	*11/05*	*12/05*	*01/06*	*02/06*	*03/06*	*04/06*
CO	**1 Hour**	**70 ppm**	**Maximum**	**ppm**	12.9	7.2	11.9	7.8	10	11.5	11
			Average	**ppm**	2.2	0.6	3.5	3.5	3.6	4.1	3.8
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
	8 Hour	**70 ppm**	**Maximum**	**ppm**	7.8	5.3	7.1	5.5	6.4	7.9	6.8
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
NO_x	**1 Hour**	**8.88 ppm**	**Maximum**	**ppm**	1.8	1.1	1.7	1.2	1.4	1.6	1.6
			Average	**ppm**	0.6	0.6	0.7	0.6	0.6	0.7	0.7
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0

Monitor Location: *VB7 Intake*

Pollutant	*Time Period*	*Emission Limits*	*Parameter*	*Unit*	*10/05*	*11/05*	*12/05*	*01/06*	*02/06*	*03/06*	*04/06*
CO	**1 Hour**	**70 ppm**	**Maximum**	**ppm**	1.2	2.7	3.9	2.9	3.7	2.1	1.2
			Average	**ppm**	0.2	0.1	0.5	0.7	0.2	0.4	0.1
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
	8 Hour	**70 ppm**	**Maximum**	**ppm**	0.9	1.3	2.4	1.8	1.7	1.2	0.7
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
NO_x	**1 Hour**	**8.88 ppm**	**Maximum**	**ppm**	0	0	0	0	0	0	0
			Average	**ppm**	0	0	0	0	0	0	0
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
PM_{10}	**24 Hour**	**500 mg/m3**	**Maximum**	**$\mu g/m^3$**	32.3	36.7	46.3	377.3	40	32.9	24.2
			Average	**$\mu g/m^3$**	13.1	18.6	18	49.7	13.6	13.9	13
			Days exceed EL		0	0	0	0	0	0	0
			Days exceed 80% EL		0	0	0	0	0	0	0

Note: EL = Emission Limit

TABLE 5-6: SUMMARY OF CO, NO_X AND PM_{10} AVERAGE AND PEAK LEVELS: VENTILATION BUILDING 7 (CONTINUED)

Monitor Location: *VB7 WB2*

Pollutant	*Time Period*	*Emission Limits*	*Parameter*	*Unit*	*10/05*	*11/05*	*12/05*	*01/06*	*02/06*	*03/06*	*04/06*
CO	**1 Hour**	**70 ppm**	**Maximum**	**ppm**	4.7	4.2	5.3	6.9	15.9	5.8	6
			Average	**ppm**	1	0.5	2.4	2	1.7	2.2	2.4
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
	8 Hour	**70 ppm**	**Maximum**	**ppm**	3.2	3.6	4.4	3.8	5.1	3.7	4.4
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
NO_x	**1 Hour**	**8.88 ppm**	**Maximum**	**ppm**	0.8	0.7	0.9	1.1	2.2	0.9	0.9
			Average	**ppm**	0.4	0.5	0.5	0.5	0.4	0.5	0.5
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0

Monitor Location: *VB7 EB2*

Pollutant	*Time Period*	*Emission Limits*	*Parameter*	*Unit*	*10/05*	*11/05*	*12/05*	*01/06*	*02/06*	*03/06*	*04/06*
CO	**1 Hour**	**70 ppm**	**Maximum**	**ppm**	10.8	7.5	15.6	7	8.7	10	11.4
			Average	**ppm**	1.6	0.7	3.3	2.8	2.4	3.2	3.4
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
	8 Hour	**70 ppm**	**Maximum**	**ppm**	6	5.6	7.5	5.2	5.2	5.9	6.5
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
NO_x	**1 Hour**	**8.88 ppm**	**Maximum**	**ppm**	1.5	1.1	2.1	1.1	1.3	1.4	1.6
			Average	**ppm**	0.5	0.6	0.7	0.6	0.5	0.6	0.6
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
PM_{10}	**24 Hour**	**500 mg/m3**	**Maximum**	**$\mu g/m^3$**	79.2	86	364.6	212.4	228.1	185	114.2
			Average	**$\mu g/m^3$**	56	59	147.2	127	106.8	102.2	71.3
			Days exceed EL		0	0	0	0	0	0	0
			Days exceed 80% EL		0	0	0	0	0	0	0

Note: EL = Emission Limit

TABLE 5-6: SUMMARY OF CO, NO_X AND PM_{10} AVERAGE AND PEAK LEVELS: VENTILATION BUILDING 7 (CONTINUED)

Monitor Location: *VB7 WB3*

Pollutant	*Time Period*	*Emission Limits*	*Parameter*	*Unit*	*10/05*	*11/05*	*12/05*	*01/06*	*02/06*	*03/06*	*04/06*
CO	**1 Hour**	**70 ppm**	**Maximum**	**ppm**	4.8	4.5	4.7	5.5	16.1	4.2	5
			Average	**ppm**	1.2	0.4	1.9	1.6	1	1.4	1.5
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
	8 Hour	**70 ppm**	**Maximum**	**ppm**	3.6	4	3.7	3.3	4.3	2.9	3.4
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
NO_x	**1 Hour**	**8.88 ppm**	**Maximum**	**ppm**	0.8	0.8	0.8	0.9	2.2	0.7	0.8
			Average	**ppm**	0.4	0.4	0.5	0.4	0.3	0.4	0.4
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0

Monitor Location: *VB7 EB3*

Pollutant	*Time Period*	*Emission Limits*	*Parameter*	*Unit*	*10/05*	*11/05*	*12/05*	*01/06*	*02/06*	*03/06*	*04/06*
CO	**1 Hour**	**70 ppm**	**Maximum**	**ppm**	14.5	9.1	13	8.6	10.6	12.4	12.2
			Average	**ppm**	2.8	0.9	4.1	3.7	3.1	3.8	3.8
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
	8 Hour	**70 ppm**	**Maximum**	**ppm**	8.4	6.8	9.1	6.7	6.1	7.7	7.3
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
NO_x	**1 Hour**	**8.88 ppm**	**Maximum**	**ppm**	2	1.3	1.8	1.3	1.5	1.7	1.7
			Average	**ppm**	0.8	0.7	0.8	0.7	0.6	0.7	0.7
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0

Note: EL = Emission Limit

TABLE 5-7: SUMMARY OF CO, NO_X AND PM_{10} AVERAGE AND PEAK LEVELS: RAMP LC-S

Monitor Location:	Ramp LC-S										
Pollutant	*Time Period*	*Emission Limits*	*Parameter*	*Unit*	*10/05*	*11/05*	*12/05*	*01/06*	*02/06*	*03/06*	*04/06*
CO	**1 Hour**	**52 ppm**	**Maximum**	**ppm**	17.7	7.7	11.6	12	4.8	8.5	7.6
			Average	**ppm**	1.9	1.4	1.6	1.8	0.9	2	1.5
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
	8 Hour	**39 ppm**	**Maximum**	**ppm**	6.8	3.1	5.6	3.8	3.2	4.1	4
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
NO_x	**1 Hour**	**6.64 ppm**	**Maximum**	**ppm**	2.4	1.2	1.6	1.7	0.8	1.3	1.1
			Average	**ppm**	0.4	0.4	0.5	0.4	0.4	0.5	0.4
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0

Note: EL = Emission Limit

TABLE 5-8: SUMMARY OF CO, NO_X AND PM_{10} AVERAGE AND PEAK LEVELS: RAMP SA-CN

Monitor Location:	Ramp SA-CN										
Pollutant	*Time Period*	*Emission Limits*	*Parameter*	*Unit*	*10/05*	*11/05*	*12/05*	*01/06*	*02/06*	*03/06*	*04/06*
CO	**1 Hour**	**70 ppm**	**Maximum**	**ppm**	22.3	6	4.7	4.4	5.8	5.2	4.6
			Average	**ppm**	1.1	1.8	1.6	1.5	1.4	1.3	1.7
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
	8 Hour	**70 ppm**	**Maximum**	**ppm**	7.6	5.3	2.9	3.2	3.1	2.9	3.2
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
NO_x	**1 Hour**	**8.88 ppm**	**Maximum**	**ppm**	3	0.9	0.8	0.7	0.9	0.8	0.8
			Average	**ppm**	0.5	0.4	0.4	0.4	0.4	0.4	0.4
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0

Note: EL = Emission Limit

TABLE 5-9: SUMMARY OF CO, NO_X AND PM_{10} AVERAGE AND PEAK LEVELS: RAMP CN-S

Monitor Location:	*Ramp CN-S*										
Pollutant	***Time Period***	***Emission Limits***	***Parameter***	***Unit***	***10/05***	***11/05***	***12/05***	***01/06***	***02/06***	***03/06***	***04/06***
CO	**1 Hour**	**67 ppm**	**Maximum**	**ppm**	13.9	16.1	13.5	21.4	15.5	15.9	14.4
			Average	**ppm**	3.8	3.2	3.9	3.9	3.5	3.8	4.3
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
	8 Hour	**58 ppm**	**Maximum**	**ppm**	7.6	7.8	8.8	6.9	7.3	7.4	8.2
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
NO_x	**1 Hour**	**8.5 ppm**	**Maximum**	**ppm**	1.9	2.2	1.9	2.8	2.1	2.2	2
			Average	**ppm**	0.8	0.8	0.7	0.7	0.6	0.7	0.8
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0

Note: EL = Emission Limit

TABLE 5-10: SUMMARY OF CO, NO_X AND PM_{10} AVERAGE AND PEAK LEVELS: RAMP CS-SA

Monitor Location:	*Ramp CS-SA no Parcel 12*										
Pollutant	***Time Period***	***Emission Limits***	***Parameter***	***Unit***	***10/05***	***11/05***	***12/05***	***01/06***	***02/06***	***03/06***	***04/06***
CO	**1 Hour**	**57 ppm**	**Maximum**	**ppm**	22.4	11.3	9.4	5.9	7.1	8.7	11.1
			Average	**ppm**	2.9	2.8	2.1	1.8	1.2	1.6	2.4
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
	8 Hour	**46 ppm**	**Maximum**	**ppm**	7.1	7	5	3.9	4.2	3.9	5.2
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
NO_x	**1 Hour**	**7.26 ppm**	**Maximum**	**ppm**	3	1.6	1.4	0.9	1.1	1.3	1.6
			Average	**ppm**	0.6	0.5	0.5	0.5	0.5	0.5	0.5
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
PM_{10}	**24 Hour**	**150 mg/m3**	**Maximum**	**$\mu g/m^3$**	73.1	102.9	278.8	137.5	139	106.5	81.3
			Average	**$\mu g/m^3$**	34.2	53.9	94.8	61.9	59.3	60.2	45.8
			Days exceed NAAQS		0	0	6	0	0	0	0
			Days exceed 80% NAAQS		0	0	11	1	2	0	0

Notes:
1. Before May 1st, 2006 PM_{10} levels were recorded inside the tunnel and therefore were not subject to NAAQS.
2. EL = Emission Limit

TABLE 5-11: SUMMARY OF CO, NO_X AND PM_{10} AVERAGE AND PEAK LEVELS: RAMP CS-P

Monitor Location:	Ramp CS-P										
Pollutant	*Time Period*	*Emission Limits*	*Parameter*	*Unit*	*10/05*	*11/05*	*12/05*	*01/06*	*02/06*	*03/06*	*04/06*
CO	**1 Hour**	**70 ppm**	**Maximum**	**ppm**	10.8	9.7	18.3	9	9.2	10	13.1
			Average	**ppm**	2.6	2.7	2.4	2.1	1.9	2.2	2.3
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
	8 Hour	**70 ppm**	**Maximum**	**ppm**	5.6	6.3	6.1	4.1	4.5	5.4	7.9
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
NO_x	**1 Hour**	**8.88 ppm**	**Maximum**	**ppm**	1.5	1.4	2.5	1.3	1.3	1.4	1.8
			Average	**ppm**	0.5	0.5	0.5	0.5	0.4	0.5	0.5
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0

Note: EL = Emission Limit

TABLE 5-12: SUMMARY OF CO, NO_X AND PM_{10} AVERAGE AND PEAK LEVELS: RAMP F

Pollutant	*Time Period*	*Emission Limits*	*Parameter*	*Unit*	*10/05*	*11/05*	*12/05*	*01/06*	*02/06*	*03/06*	*04/06*
CO	**1 Hour**	**70 ppm**	**Maximum**	**ppm**	4	9.6	3.7	3.9	3.4	3.4	3.7
			Average	**ppm**	0.8	1.5	0.9	1.1	0.9	1.4	1.3
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
	8 Hour	**70 ppm**	**Maximum**	**ppm**	2.5	3.4	2.8	2.8	2.5	2.5	2.8
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0
NO_x	**1 Hour**	**8.88 ppm**	**Maximum**	**ppm**	0.7	1.4	0.7	0.7	0.6	0.6	0.7
			Average	**ppm**	0.4	0.4	0.3	0.3	0.3	0.4	0.4
			Hours exceed EL		0	0	0	0	0	0	0
			Hours exceed 80% EL		0	0	0	0	0	0	0

Note: EL = Emission Limit

TABLE 5-13: SUMMARY OF CO, NO_X AND PM_{10} AVERAGE AND PEAK LEVELS: DST I-93

r Location: Ramp DST-I-93 Existing

Time Period	Emission Limits	Parameter	Unit	10/05	11/05	12/05	01/06	02/06	03/06	04/06
1 Hour	25 ppm	Maximum	ppm	25.8	22	24.8	20.9	22	23.5	25
		Average	ppm	5.8	5.1	5.3	4.7	5.1	4.4	5.4
		Hours exceed EL		4	0	0	0	0	0	0
		Hours exceed 80% EL		10	2	12	1	2	2	3
8 Hour	23 ppm	Maximum	ppm	13.1	10.7	13.7	10.9	11.5	11	13
		Hours exceed EL		0	0	0	0	0	0	0
		Hours exceed 80% EL		0	0	0	0	0	0	0
1 Hour	3.3 ppm	Maximum	ppm	3.4	2.9	3.3	2.8	2.9	3.1	3.3
		Average	ppm	0.9	0.8	0.9	0.8	0.8	0.8	0.9
		Hours exceed EL		4	0	0	0	0	0	0
		Hours exceed 80% EL		10	2	12	1	2	2	3

Notes:
1. EL = Emission Limit
2. Air quality analysis performed for each hour when EL was exceeded demonstrated that no violations of the Massachusetts 1-hour NO_2 Policy Guideline Limit had occurred. (Appendix E).

TABLE 5-14: SUMMARY OF CO, NO_X AND PM_{10} AVERAGE AND PEAK LEVELS: DST I-90

r Location: Ramp DST-I-90 Existing

Time Period	Emission Limits	Parameter	Unit	10/05	11/05	12/05	01/06	02/06	03/06	04/06
1 Hour	25 ppm	Maximum	ppm	21	25.3	34.8	19.7	20.1	19.6	21.2
		Average	ppm	2.2	4.5	4.2	4.1	4.2	4.5	4.8
		Hours exceed EL		0	1	2	0	0	0	0
		Hours exceed 80% EL		2	1	8	0	1	0	2
8 Hour	23 ppm	Maximum	ppm	11.3	11.4	12.2	9.6	11.5	10.6	13.1
		Hours exceed EL		0	0	0	0	0	0	0
		Hours exceed 80% EL		0	0	0	0	0	0	0
1 Hour	3.3 ppm	Maximum	ppm	2.8	3.3	4.5	2.6	2.7	2.6	2.8
		Average	ppm	0.8	0.8	0.8	0.7	0.7	0.8	0.8
		Hours exceed EL		0	1	2	0	0	0	0
		Hours exceed 80% EL		2	1	8	0	1	0	2

Notes:
1. EL = Emission Limit
2. Air quality analysis performed for each hour when EL was exceeded demonstrated that no violations of the Massachusetts 1-hour NO_2 Policy Guideline Limit had occurred (Appendix E).

Part IV - Corrective Actions

6 CONTINGENCY PLAN

6.1 GENERAL REQUIREMENTS (310 CMR 7.38(4))

"… the operating certificate submittal shall include a contingency plan consisting of measures which could be implemented in cases of exceedance of the emission limitations in the certificate. Said contingency plan shall identify available contingency measures including, but not limited to, alternative tunnel ventilation system operations and maintenance, and transportation control measures; a commitment for implementing said measures; a schedule for implementing measures on a days-to-full effectiveness basis; and an analysis of the daily air quality impact of the measures on the emissions from the tunnel ventilation system and within the project area."

6.2 COMPLIANCE STATUS DETERMINATION FOR DAY-TO-DAY OPERATIONS

Concentration based emission limits for CO, NO_x and PM_{10} were established as discussed in Section 2 of this document for tunnel emission exhaust locations. The limit levels that were established ensure that applicable NAAQS for CO, NO_2 and PM_{10} and the Mass DEP 1-hour NO_2 Policy Guideline Value for NO_2 will not be exceeded at any ambient (i.e., outside) receptor location.

In order to determine the compliance status of the tunnel emissions, the Project has installed a separate CO and PM_{10} CEM (continuous emission monitoring) system as described in Section 3 and Attachment 1 of this document. Data collected from the CO and PM_{10} CEM system are compared to the emission limits for every emission location.

It is worth noting that based on discussion with Mass DEP it is MTA understanding that the 310 CMR 7.38(2) requirements regarding compliance with the applicable ambient air quality standards and the State Policy guideline for nitrogen dioxide would not apply during emergency conditions (i.e., tunnel fires).

The established emission limits for each location are listed as follows:

TABLE 6-1: SUMMARY OF EMISSION LIMITS

Location*	1-Hr CO Emission Limit (ppm)	8-Hr CO Emission Limit (ppm)	1-Hr NO_X Emission Limit (ppm)	24-Hr PM_{10} Emission Limit ($\mu g/m^3$)
VB 1	70	70	8.88	500
VB 3	70	70	8.88	500
VB 4	70	70	8.88	500
VB 5	70	70	8.88	500
VB 6	70	70	8.88	500
VB 7	70	70	8.88	500
Ramp L-CS	52	39	6.64	NA
Ramp CN-S	66	58	8.38	NA
Ramp SA-CN	70	70	8.88	NA
Ramp CS-SA	56	46	7.14	150**
Ramp ST-SA	70	51	8.88	NA
Ramp CS-P	70	70	8.88	NA
Dewey Sq. Tunnel	25	23	3.30	NA
Ramp F	70	70	8.88	NA

* For VBs, location includes all ventilation zones of this VB.

** The ambient PM_{10} monitor is located outside ramp CS-SA. See section 3.3.4.2 for details.

As described in Section 2.4.3 of this document, emission limits for NO_x were established using a statistical analysis of actual CO and NO_x emission data collected from the TWT. The 1-hour CO emission limits listed above were established taking into account 1-hour NO_2 impacts. As a result, if the 1-hour CO emission levels remain below the listed emission limit, then no exceedances in the Massachusetts 1-hour NO_2 Policy Guideline Limit should occur.

6.3 PRE-EMPTIVE ACTIONS

In order to avoid exceedances of the emission limits and ensure compliance with the applicable air quality standards, two tiers of pre-emptive measures are applied.

First, the in-tunnel CO monitoring system that is used to control tunnel ventilation and maintain in-tunnel air quality, is set to alarm at a 25 ppm CO level. In response to an alarm, an OCC operator will lower the in-tunnel CO level to below 25 ppm by increasing the ventilation rate at the affected ventilation zone.

The second tier of pre-emptive measures involves the CEM system. The 1-hour CO and 8-hour PM_{10} CEM emission action levels have been established for each emission location and actions will be taken (i.e., ventilation of the affected zone or zones increased) to lower the pollutant levels inside the tunnel when these action levels are exceeded. The action level established for each emission location falls within a range between 75 to 85% of its respective emission limit as listed below.

TABLE 6-2: EMISSION ACTION LEVELS

Location*	CO Emission Action Levels (ppm)	8-Hr (8 AM to 4 PM) PM_{10} Emission Action Levels ($\mu g/m^3$)
VB 1	60	NA**
VB 3	60	500
VB 4	60	NA**
VB 5	60	500
VB 6	60	NA**
VB 7	60	500
Ramp L-CS	42	NA
Ramp CN-S	53	NA
Ramp SA-CN	60	NA
Ramp CS-SA	47	120***
Ramp ST-SA	60	NA
Ramp CS-P	60	NA
Dewey Sq. Tunnel	20	NA
Ramp F	60	NA

* For VBs, location includes all ventilation zones of this VB.
** VB 1, 4 and 6 do not have PM_{10} monitors. Action levels at VB 3, 5 and 7 will be used as surrogate for these locations.
*** Action level for ramp CS-SA is for 24 hours and is set to 80% of the 24-hour PM_{10} NAAQS.

Real-time CO emissions for all CO CEM monitoring locations except VB 6 and 7 are provided in the Operation Control Center for operator use. Using CO action levels presented in Table 6-2, procedures will be established for the OCC that will trigger an OCC operator response in the event that a CEM action level is reached.

In order to comply with the lowest emission action level (i.e., 20 ppm for DST), the ventilation fans for the Dewey Square Air Intake Structure along with ventilation zone SB-1 from VB 3, will be set to step 3 from 3 p.m. to 6 p.m. each weekday afternoon. The increase in the ventilation zone settings should prevent hourly CO emission levels from going above 20 ppm for DST. If however, the emission action level for DST is exceeded because of a non-emergency situation, the ventilation will be stepped up to a higher setting to ensure emission level remains below the emission action level.

Because of the high CO emission action levels for VBs 6 & 7, recorded CO CEM emission levels will be tracked for one continuous year. If CO emission levels remain well below the 60 ppm action level listed in Table 6-2 as anticipated, MTA will not proceed to establish a CO CEM display for these two locations. However, if CO emission levels are near the 60 ppm action level, then the CEM monitors from VBs 6 & 7 will be displayed in the OCC.

In addition, PM_{10} CEM emissions levels are also not displayed in the OCC. However, similar to CEM CO emissions from VBs 6 & 7, CEM PM_{10} emission levels from VBs 3, 5, 7 and ramp CS-SA will also be tracked for one continuous year. Likewise, if PM_{10} emissions are near the 8-hour 500 $\mu g/m^3$, then PM_{10} emission levels will be displayed in the OCC. However, because of the high 8-hour emission action level of 500 micrograms per cubic meter, it is very unlikely that this level will ever be reached.

In summary, it is extremely unlikely that any of the CEM emission action levels listed in Table 6-2 will ever be reached due to the deployment of the pre-emptive actions.

6.4 CORRECTIVE (CONTINGENCY) ACTIONS

6.4.1 Emission Limit Exceedance Notification

In the unlikely event that an exceedance of an emission limit from any of the emission locations does occur, the MTA will immediately verbally notify the Mass DEP. The written notification will be followed to Mass DEP within 24 hours of determination of an exceedance. Provided that the necessary ozone and NO_2, or CO, or PM_{10} background concentrations are supplied to MTA by Mass DEP, results of the emission limit assessment analysis report will be submitted to the Mass DEP in three business days from the time when the background data is received along with the actions that have been taken to eliminate the emission limit excursion.

6.4.2 Emission Limit Assessment

If an exceedance in an emission limit occurs from any of the emission locations, an air quality analysis will be performed to determine if the exceedance resulted in a violation of either CO, or NO_2, or PM_{10} NAAQS or the Massachusetts 1-hour NO_2 Policy Guideline Limit for the particular time period when exceedance occurred. The analysis will examine air quality impacts for each designated receptor around the VB or longitudinally ventilated exit ramp where exceedance occurred. Meteorological conditions and pollutant background concentration during the exceedance time period will be used in the analysis. The results of the analysis will be reported to the Mass DEP along with the emission limit exceedance notification.

6.4.3 Additional Contingency Measures

Because of the deployment of two tiers of pre-emptive actions, it is extremely unlikely that any of the pre-set CEM emission action levels will ever be reached. Thus, development of further contingency plan measures to mitigate an unlikely violation of an emission action levels, is not warranted at this time.

6.5 MITIGATION PLAN

As indicated in the 310 CMR 7.38(4), this section of the regulation does not require the inclusion of a mitigation plan in the initial operating certificate submittal. The preparation, review and acceptance of a mitigation plan is instead governed by 310 CMR 7.38(6).

310 CMR 7.38(6) states that if Mass DEP finds—based on a review of information submitted by the operator in support of the operating certification, and such information as Mass DEP has available to it—that one or more of the air quality limits set forth in the 7.38 Criteria are being violated or are likely to be violated, then the operator of the tunnel ventilation system shall take certain identified actions. The trigger to taking those actions then is a finding of a violation of air quality standards based on Mass DEP review of the operating certification submittal itself.

It is unlikely that even the emission action levels will be exceeded at any VB or longitudinally ventilated ramp because of the measures designed to preclude this from happening. Several preventive steps will be undertaken to ensure compliance with emission limits before any mitigation measures will be considered. Those steps are described above in sections 6.2 and 6.3. First, tunnel ventilation system is operated to maintain 25 ppm CO levels inside the tunnel which is below most limits. Secondly, CEM monitoring system warns operators if the action level (75-85% of emission limit) is reached. Finally, operators will be alarmed if emission limit is exceeded. In each case, OCC operators will increase ventilation rates in order to bring emissions in the tunnel below the indicated criteria. If emission limit is still exceeded at any location, procedures described in section 6.4 above will be followed and an assessment will be performed to analyze air quality impacts for the particular hour/day of exceedance and to demonstrate whether an exceedance of the emission limit indeed created an exceedance of the NAAQS or a Mass DEP Policy Guideline.

The corrective actions established to comply with the contingency plan requirements of 310 CMR 7.38(4) should be effective in reducing emission levels in the event that any of the established action limits are exceeded due to non-emergency traffic conditions. Because information regarding the development of a CA/T mitigation plan is required only in the event that Mass DEP finds that one or more of the 7.38 criteria are being violated, unless and until Mass DEP makes such a finding, including but not limited to an identification of the nature and severity of the violation, appropriate mitigation measures are not required to be developed.

6.6 OPERATING CERTIFICATION CRITERIA

In summary, MTA has demonstrated that the operation of the CA/T Project's tunnel ventilation system is in strict accordance with the certification criteria set forth in 310 CMR 7.38 (2) (a) through (c) and the Certification accepted by Mass DEP pursuant to 310 CMR 7.38 (3), as demonstrated through actual measured emissions data, through the establishment of and compliance with emission limits for the Project area, through the creation and implementation of Project's CEM program and through the development and, if necessary, the implementation of the Project's Contingency Plan, all as described and verified in this Operating certification Document.

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